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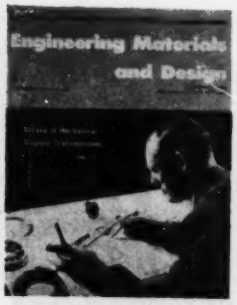

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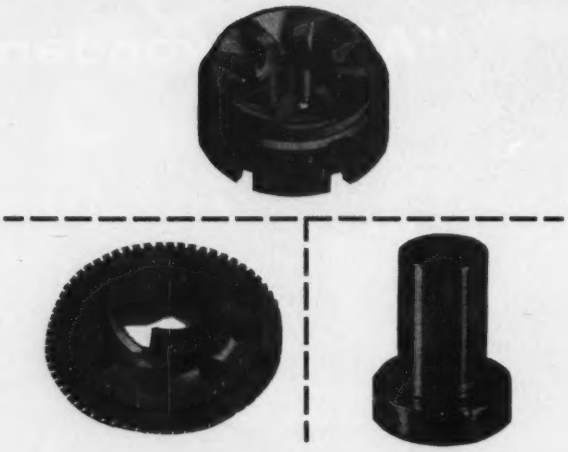

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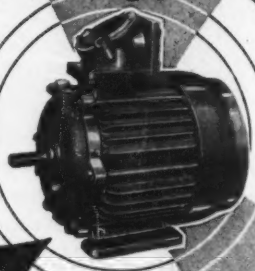

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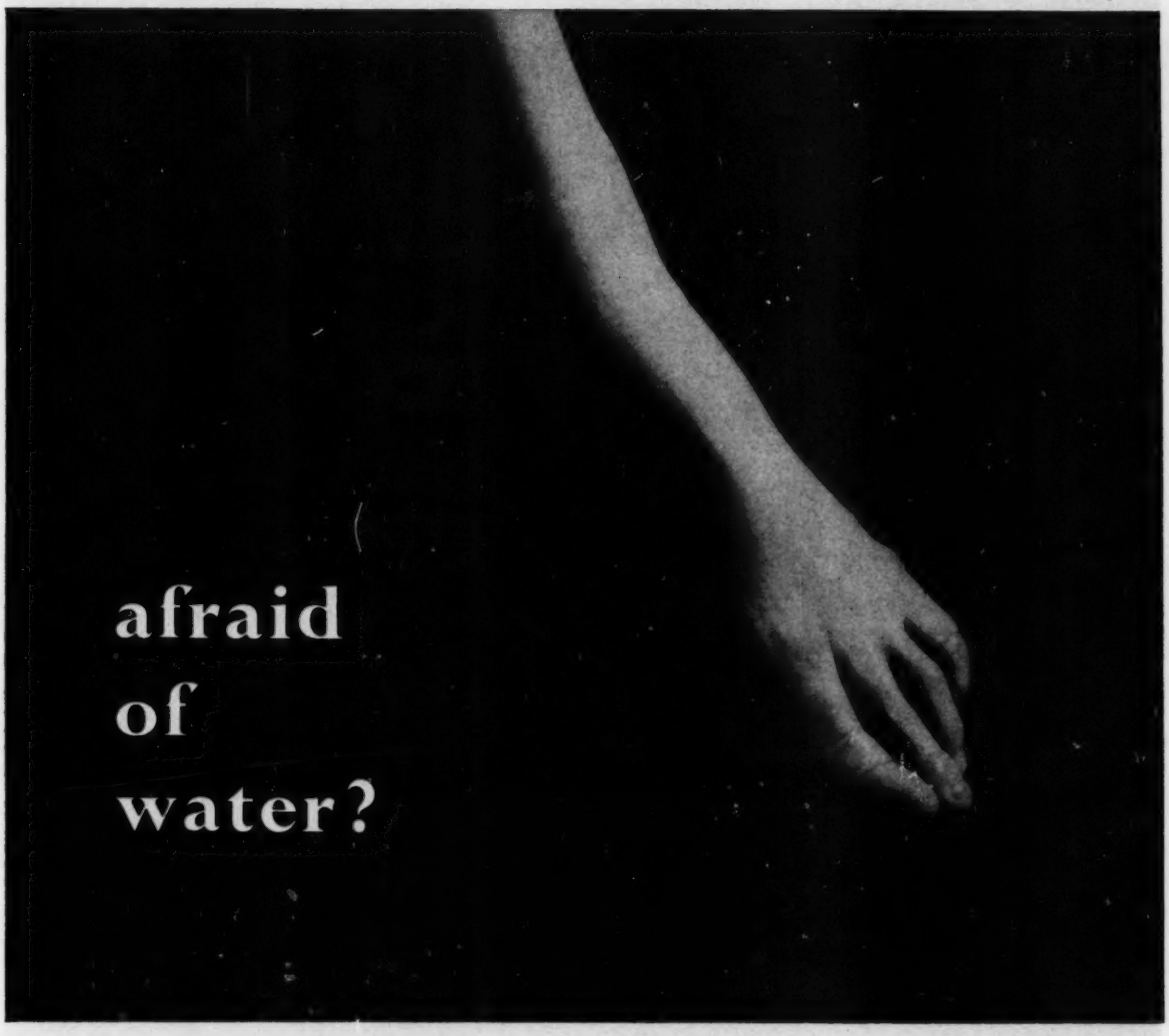

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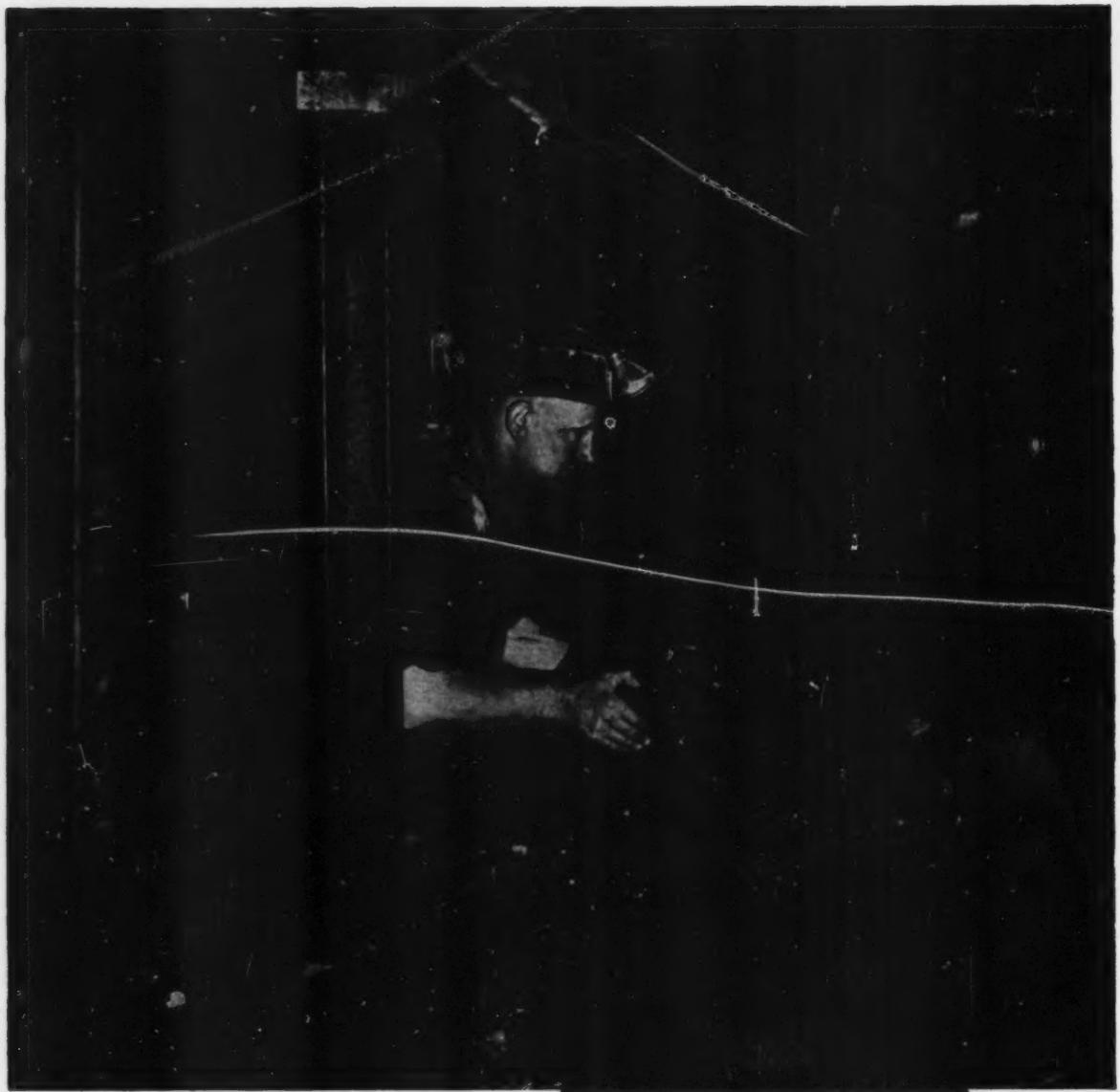

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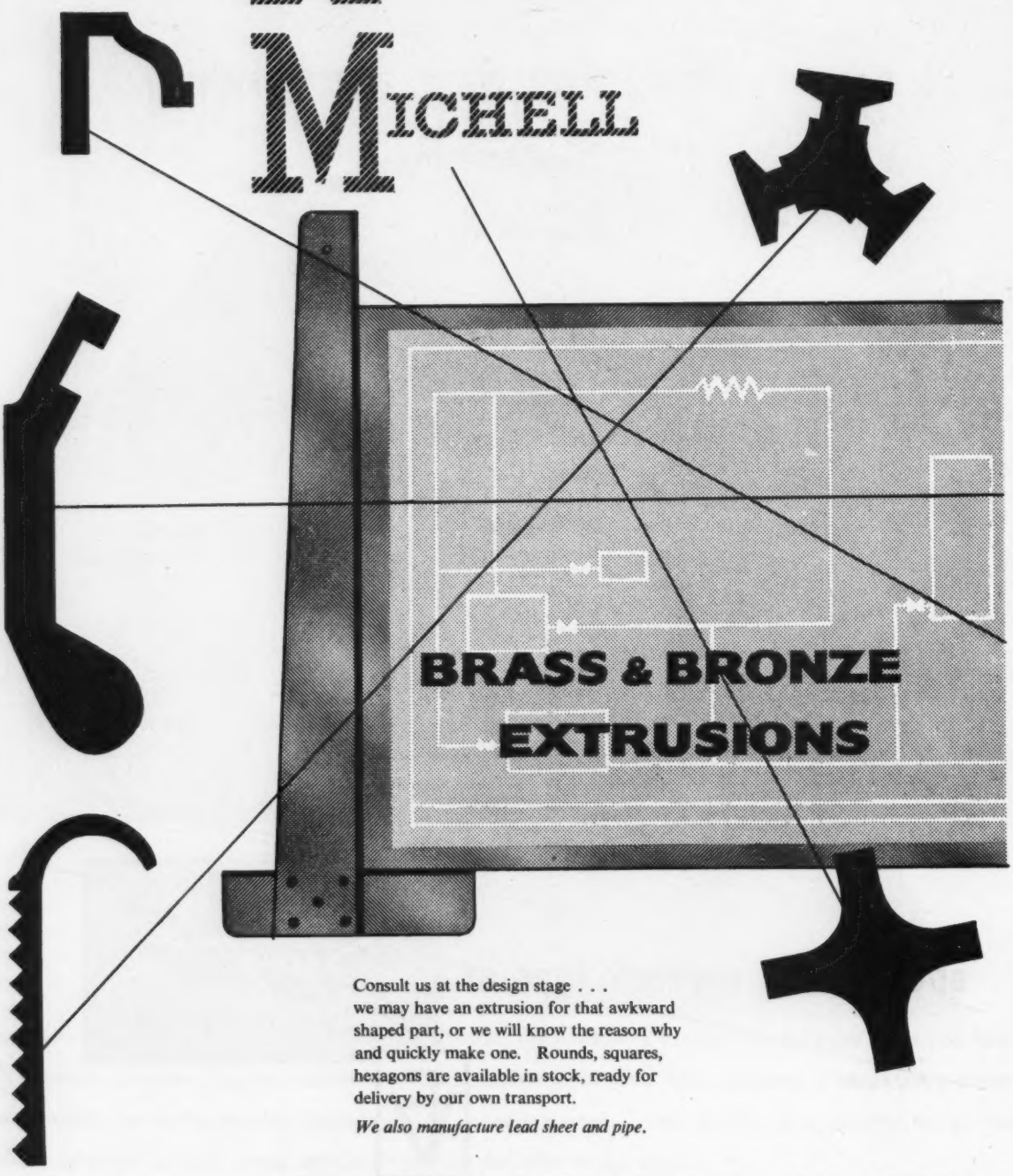

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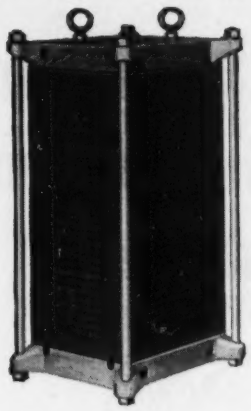

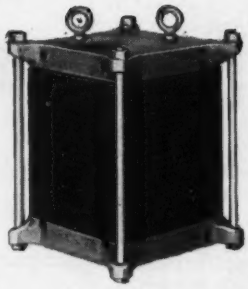

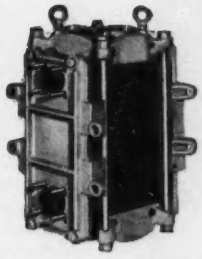

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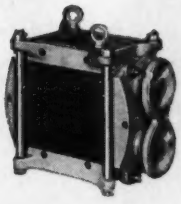

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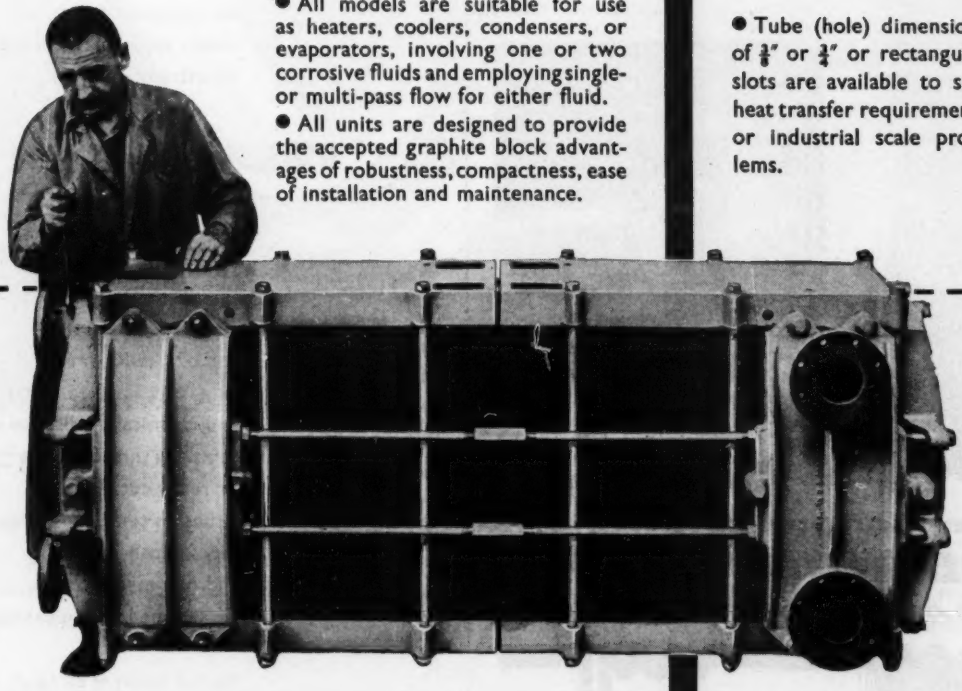

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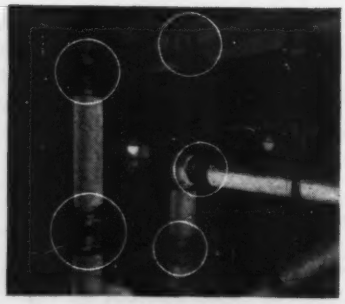

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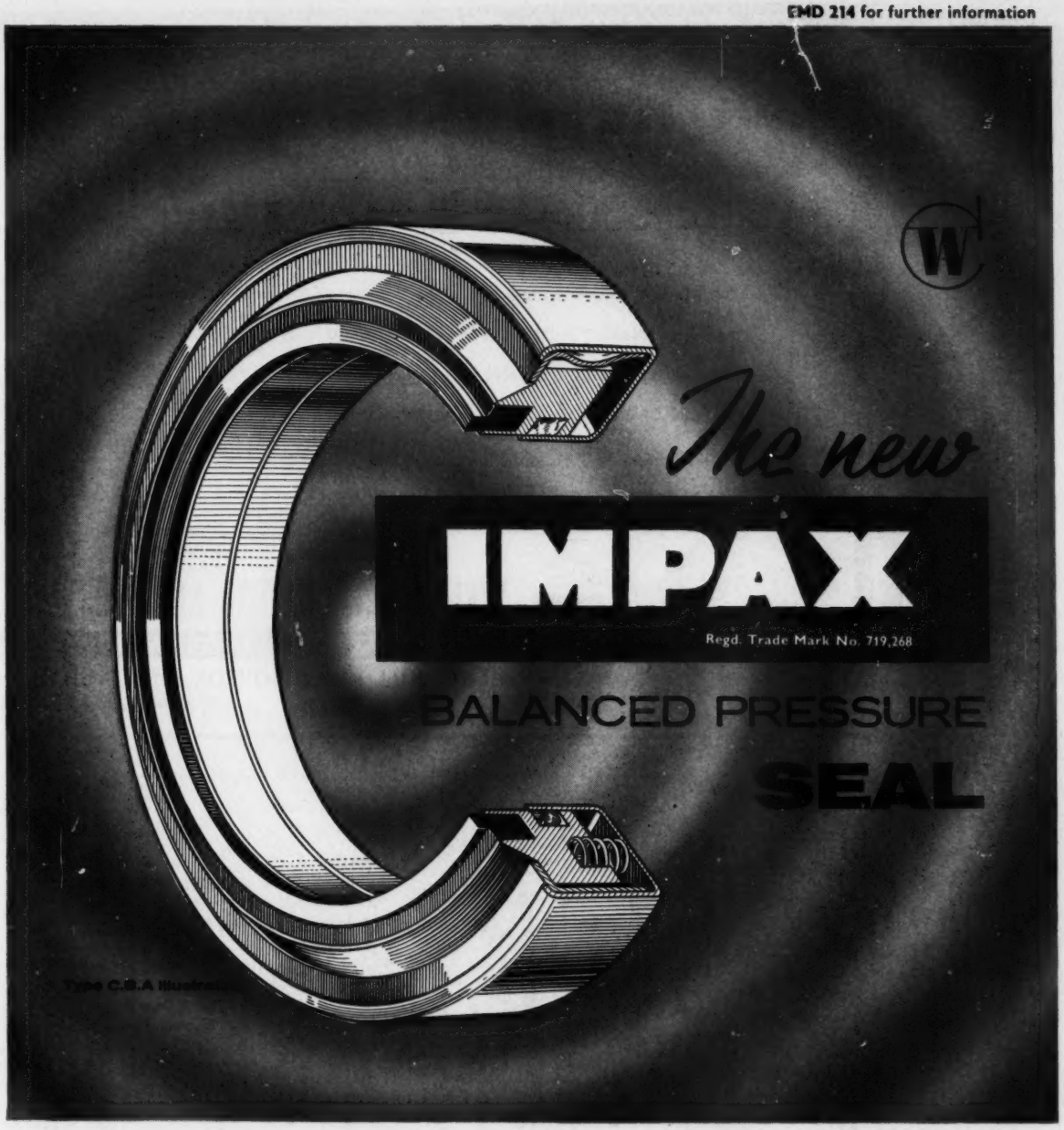

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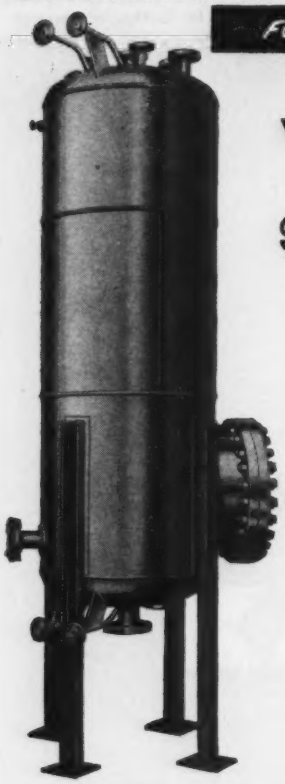

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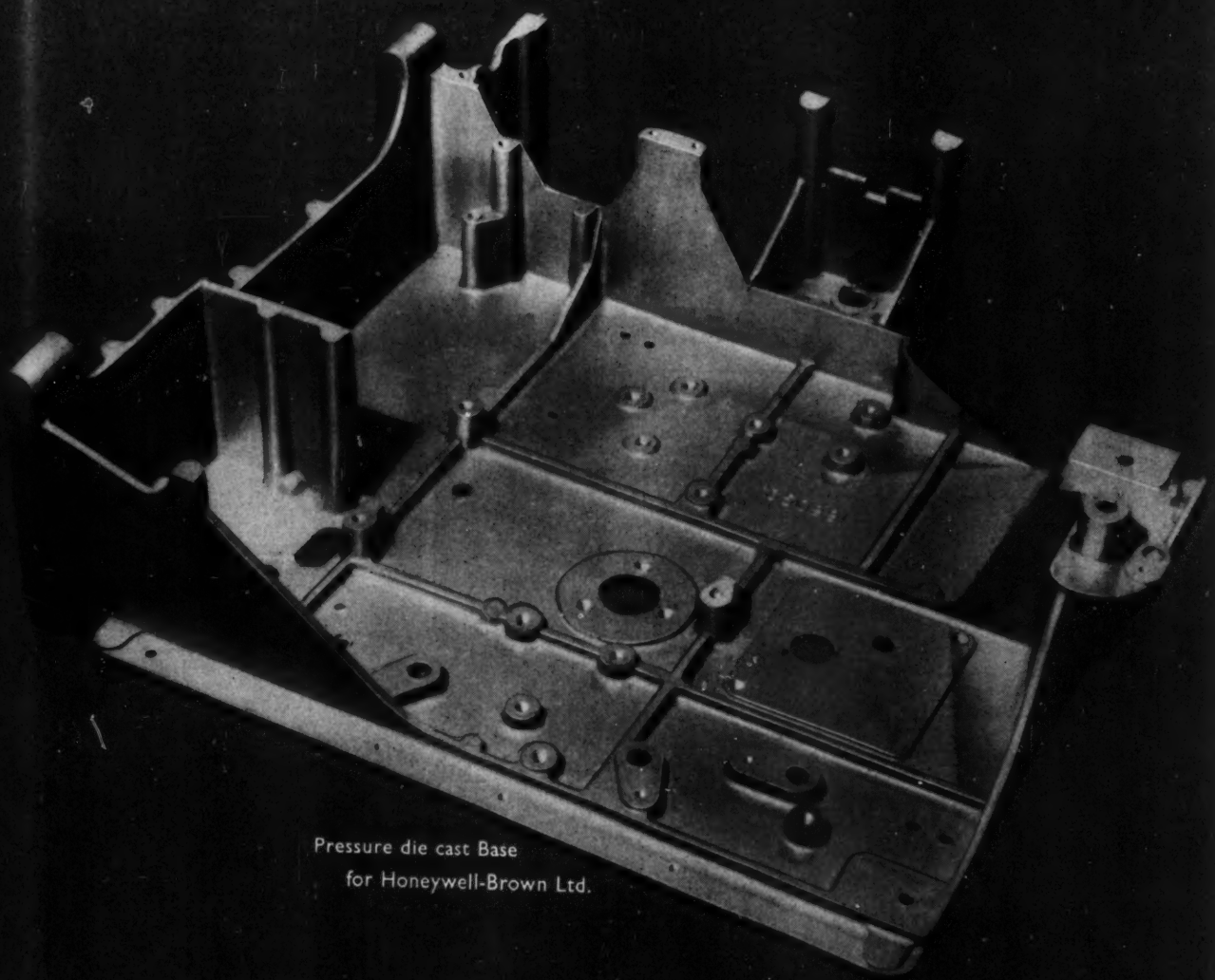

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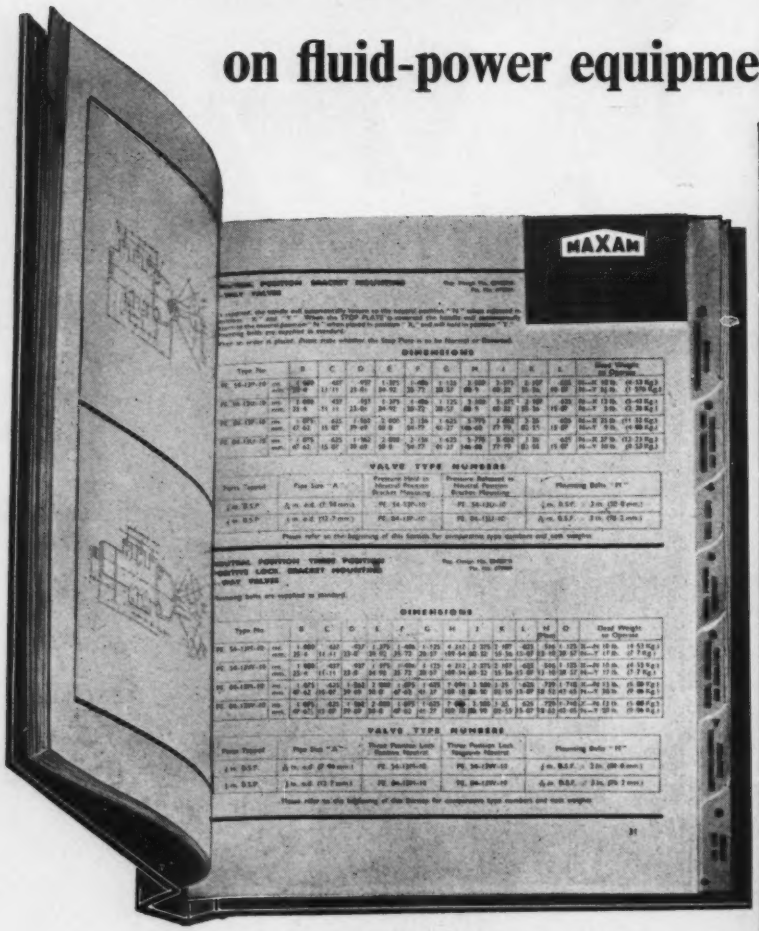

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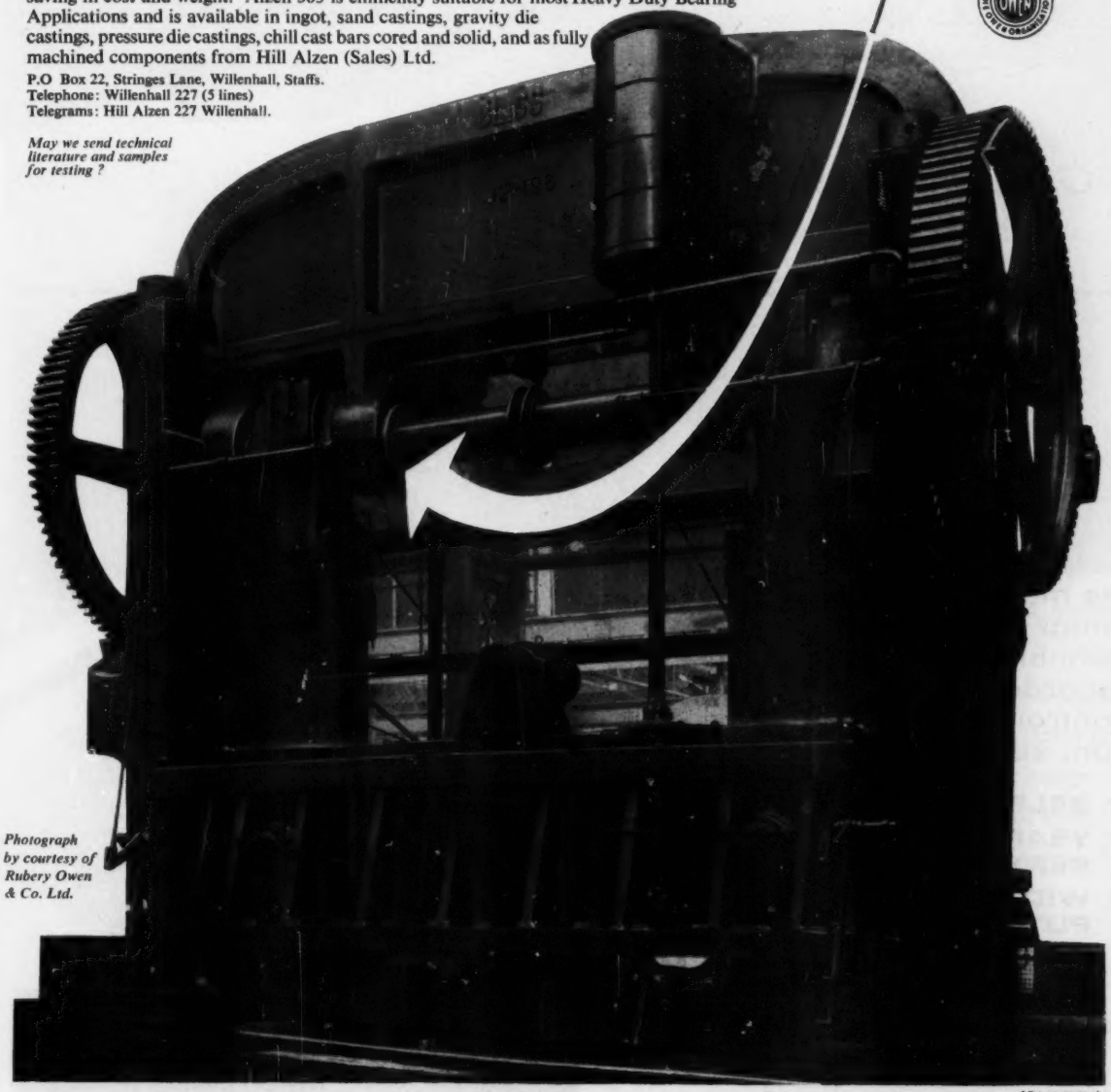

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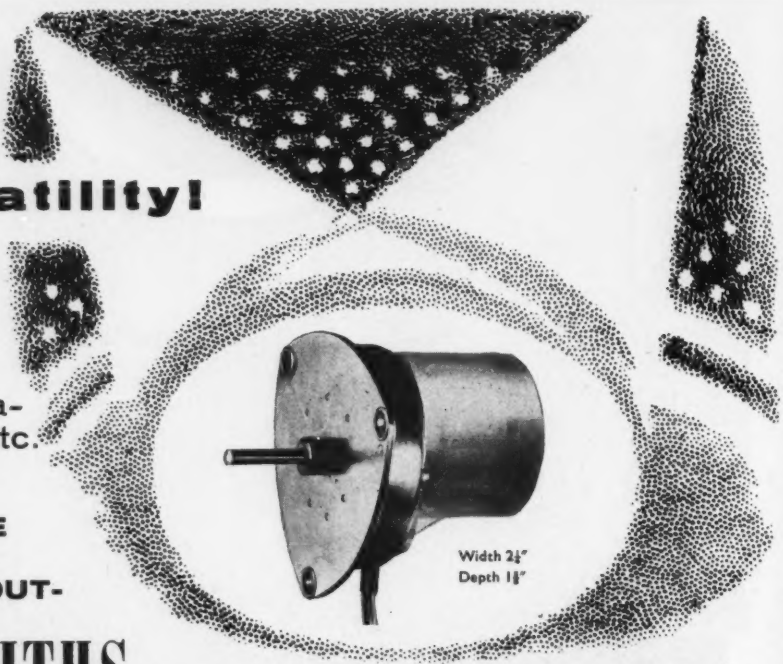

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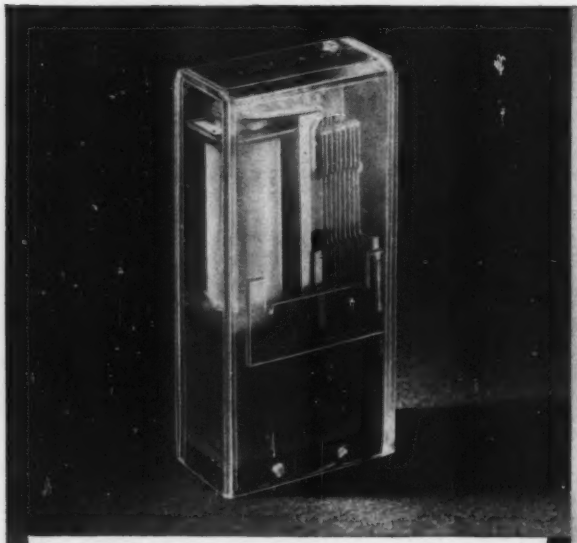

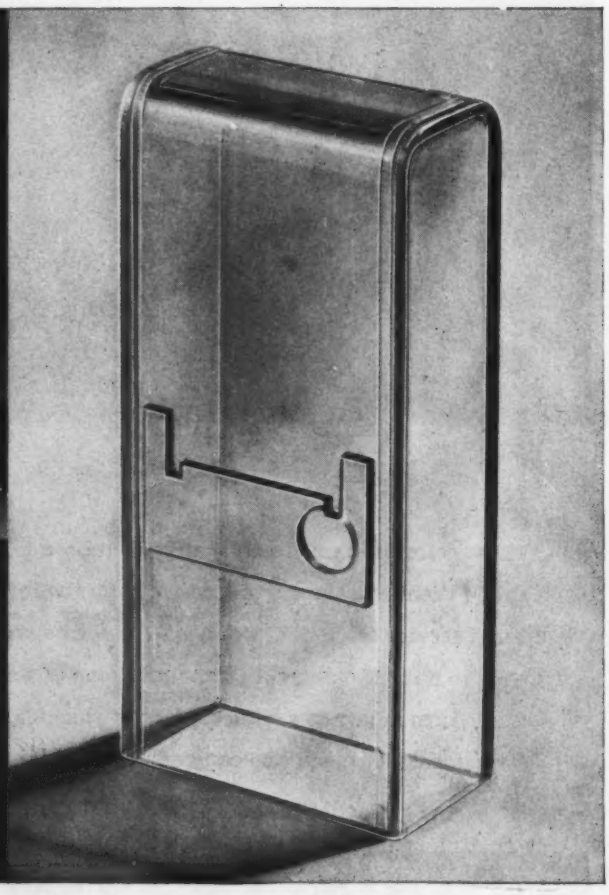

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MATERIALS IN THE NEWS

Monthly Digest of Materials and Design News from Home and Abroad

British Synthetic Rubber

WHAT is claimed to be the world's most modern synthetic rubber plant is now operating at Hythe, on Southampton Water. It is operated by the International Synthetic Rubber Co. Ltd. and is Britain's first venture into the bulk manufacture of general purpose synthetic rubber. The rubber being produced is known as SBR and is manufactured from styrene and butadiene.

A large proportion of the output is used for vehicle tyres where it imparts improved resistance to abrasion but it is complementary to natural rubber, which has superior resilience. Passenger car tyres may have up to 45 per cent synthetic rubber in their composition; commercial vehicle tyres also incorporate it, but to a lesser extent.

It has been pointed out that by manufacturing the synthetic rubber in this country the possible dollar saving on imported material is more than 25 million dollars.

Aluminium for I.C. Engines

CONSIDERABLE RESEARCH has recently been carried out by the Aluminium Co. of America and by General Motors into the use of aluminium alloys for cylinder blocks of engines. Although aluminium has been used for many years for certain parts, such as sumps and heads, the principal difficulty in using it for engine blocks has been the cost and poor wear resistance at points of maximum friction.

The use of aluminium to replace cast iron not only reduces the weight of the engine but allows a weight reduction to be made in the supporting structures, thereby considerably decreasing the overall weight of the vehicle. If a wear-resistant aluminium alloy can be developed, even further weight reduction might be possible for other applications than the engine.

Experiments with high-silicon alloys have shown remarkable wear resistance which is claimed to approach that of a chrome-plated cylinder lining. The use of aluminium alloys opens up new fields for engine design by virtue of their high thermal conductivity which means that volumetric efficiency is improved. Furthermore, production methods, such as pressure die-casting, can be considered as a means of reducing overall costs.

Niobium—Its Future

UNTIL recently niobium, or columbite, as it is known in mining circles, was being stockpiled as a material of strategic importance for both guided missile and supersonic aircraft development. This particular demand has now virtually ceased.

At the same time, the metal has not yet established itself—partly due to its high cost—as a material for commercial use in the engineering industry, although many potential applications in high temperature engineering can be foreseen. Niobium has a melting point of 1950 deg. C. and can be alloyed with other metals quite readily to give both increased hardness and temperature resistance.

A new use for niobium is, however, developing and may well within the next four or five years offset the situation caused by the falling off of demand for this material for guided weapons manufacture. This is in nuclear engineering: here niobium seems to have considerable potentialities as an alloying material, combined with other metals to produce zirconium-like alloys for structural engineering and fuel element casing purposes.

Recent Russian work in this field—in which the U.K. Atomic Energy Authority has long been active—seems to have been particularly striking and indicates that considerable demand for this metal may once again arise on the basis of the growth of a relatively specialised industry. The indications are, however, that the new demand is likely to be more permanent than that created by guided weapons.

Non-destructive Testing

MIDLAND engineers had a chance to see the new model 17 Hanovia ultra-violet fluorescent lamp under working conditions at a recent exhibition in Birmingham organised by Engelhard Industries Ltd. The lamp was developed to facilitate the non-destructive testing of larger components using fluorescent ink methods.

With the lamp 5 ft. from the area to be viewed, distinctive fluorescence is obtained along 11 ft. of the central axis of the lamp. The rectangular metal housing, containing a 2-kW. medium-pressure vapour lamp mounted between the reflector and the heat-resistant filter glasses, is designed for suspension over an inspection bench. The lamp is cooled by means of a centrally-mounted fan.

The lamp is used for the testing of crankshafts, steel tube, rod and sheet, large forgings, and engineering components on a conveyor in an inspection bay. It can also be used to locate oil leaks in transformers and capacitors.

Protecting Concrete

CONCRETE is one of the most widely used industrial structural materials. At the same time, it is also very susceptible to certain types of erosion or chemical attack. For this reason a number of new coating processes have been developed for use in the protection of both concrete pipes and concrete reservoirs. These range from the use of bituminous paint, or silicones, to the use of specially-developed ceramic coatings.

One problem which has played a large part in the use of such coatings is the difficulty and cost of applying them. A new coating technique which has been developed in the U.K. can be used, however, it is claimed, to apply protective bituminous, or other types of coatings to concrete pipes of up to three feet diameter, or to concrete reservoirs at an exceptionally rapid rate. Tests carried out with the process, which has been patented, are said to have shown, for example, that it can apply three layers of bituminous protective paint coats to a three-foot diameter pipe in fourteen minutes. This compares with an application time of about ten hours for conventional processes.

Timber Lighting Standards

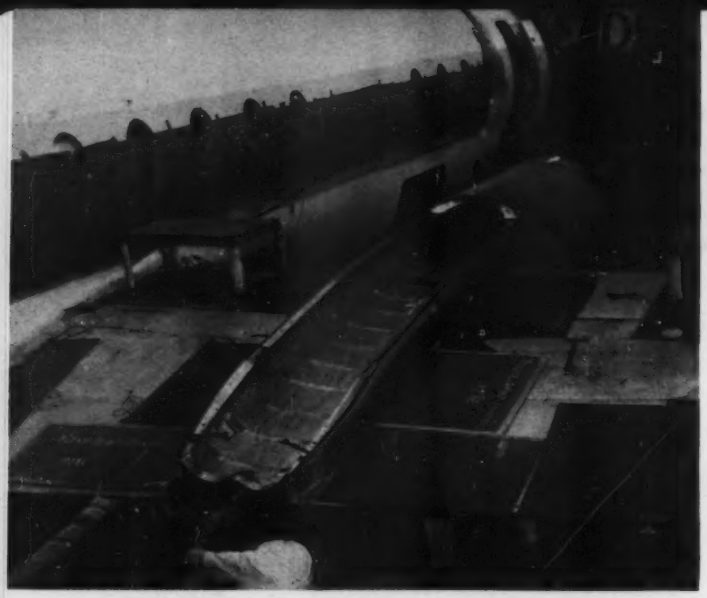
THE USE of timber has been proposed for a number of lighting schemes—including that for a major re-planning scheme in London—and timber street lighting columns were recently shown for the first time by Siemens Edison Swan Ltd. at the Association of Public Lighting Engineers' Exhibition. In certain locations, their appearance can be preferable to that of concrete or steel.

Malayan kapur was selected for this purpose as it is sufficiently durable to be set direct into concrete without the need for a special base.

All timber used is kiln dried and the columns are made of four boards laminated with a phenol-resorcinol glue. The wiring and control gear are housed in the hollow centre and a metal fitting at the top of the column is designed to receive the lantern and show as little as possible of the fitting itself.

PICTURE NEWS

IN THE WORLD OF MATERIALS & DESIGN



STEEL AND SILICA SHROUD

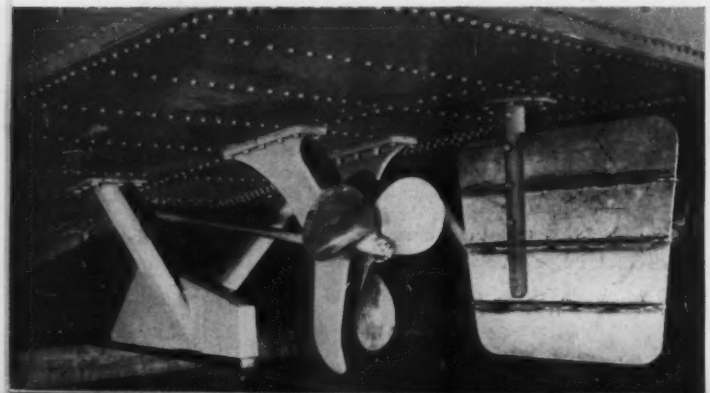
This 13-ft. heat shroud for the Vickers Vanguard is of silica sandwiched between two sheets of 0.004-in. gauge stainless steel. In production by Delaney Gallay Ltd., it provides 48 sq. ft. of insulation for a weight penalty of 34½ lb.

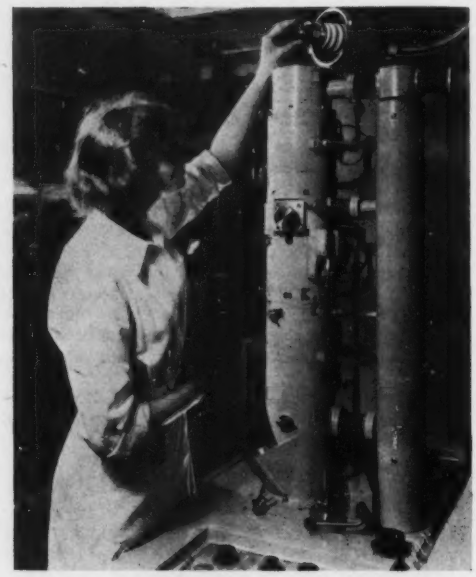
DOUBLE-OPERATOR WELDING

To fabricate a large cylindrical $\frac{1}{16}$-in. copper vessel, W. Broady & Sons of Hull used a double-operator vertical welding technique with hand-welding blowpipes supplied by British Oxygen Gases Ltd. Higher welding speeds and greater economy of gas and rod are possible this way, and thicker metal can be welded without specially prepared edges.

FABRICATED ALUMINIUM RUDDERS

Two 60-ft. cargo lighters built for the Royal Pakistan Navy by Whittingham & Mitchel Ltd. are of all-aluminium construction for use in shallow waterways. All plating in the hull is $\frac{1}{16}$-in. Noral B54S alloy. Twin fabricated aluminium rudders are mounted on stainless steel stocks, passing upwards through aluminium tubes with water-lubricated rubber bearings at the lower end.



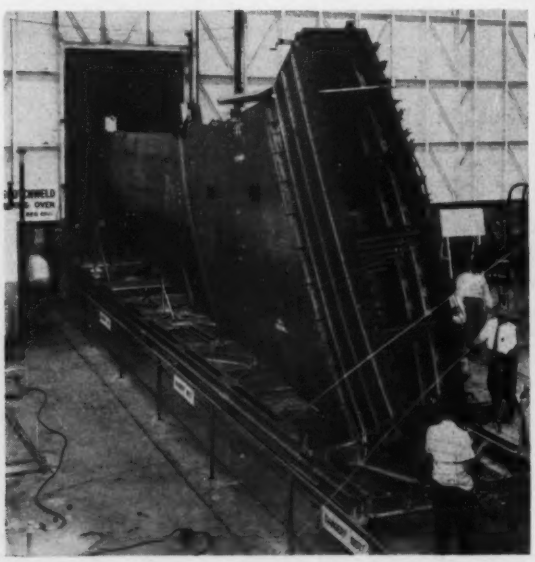


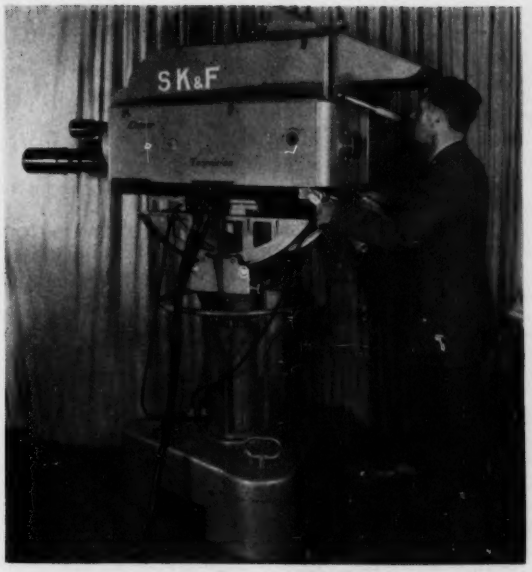
ELECTRON MICROSCOPE

One of the most advanced examples of electron optical design is this Metropolitan-Vickers type EM6 electron microscope installed at the Royal College of Surgeons. It has a magnification of 120,000x, with a binocular telescope for further magnification of 10x.

BONDING CONVAIR WINGS

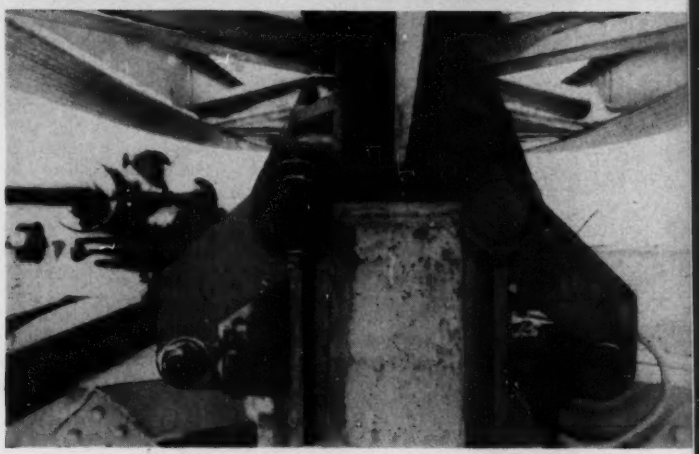
The wings of the Convair 880—due to make its first flight early in the New Year—are cured in this electric oven for an hour at 160 deg. C. This is the final step in the Scotchweld adhesive bonding process used in fabricating the integral fuel tanks.





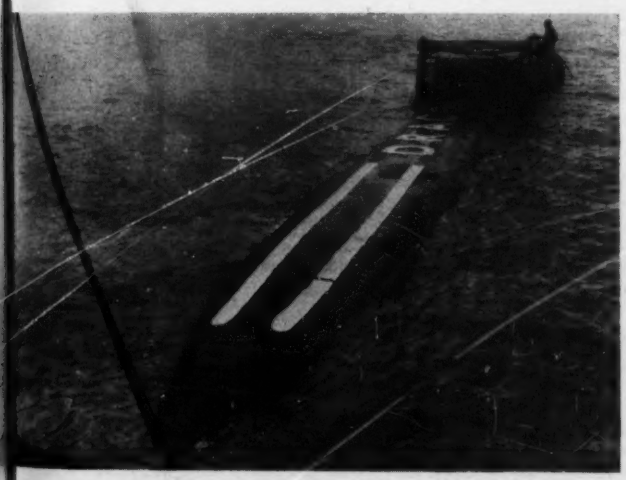
FIRST MOBILE TELEVISION UNIT

Britain's first mobile medical colour television unit uses a three-tube Marconi Image Orthicon. It will be used for medical and surgical demonstrations. Polyethylene-insulated 88-way cable was designed by B.I.C.C. for use in colour television equipment of this kind.



BRAKE LININGS ON RADIO TELESCOPE

Brake linings provide control for the 300-ft. stabilising track of the Jodrell Bank radio telescope, which recently helped to track the U.S. moon rocket. Top picture shows the two stabilising clamps (in foreground) and one of the bogies, the drum brakes of which have Ferodo brake linings. In the lower picture can be seen some detail of one of the clamps which hold the 750-ton bowl structure; the woven asbestos strip linings (32 in. x 6 in. wide) can be seen gripping the centre flange.



COLLAPSIBLE BARGE FOR LIQUIDS

Intended to carry about 10,000 gallons, this flexible towed container has a $\frac{1}{32}$-in. stressed skin of woven nylon fabric with synthetic rubber coating inside and out. Made for Dracone Developments Ltd. by P. B. Cow & Co. Ltd., it can be emptied and rolled up for cheap return transport as deck cargo. It kinks when changing direction in the water and, in a collision, causes or suffers no damage.

EPOXY-GLASS TUBING FOR JIGS

This jig, used by de Havilland to position parts in the wheel well of the Comet IV (the wing is inverted for the job), consists of lengths of epoxy resin-glasscloth laminate tubing, bonded together with an Araldite mixture and glasscloth tape, to provide a structure of great rigidity and stability. If less strength is needed, the glasscloth tape is dispensed with, and the framework may be bonded with a heavily-filled resin of putty-like consistency.

Fatigue Testing at Cranfield

THE College of Aeronautics at Cranfield, which recently held its Open Day, is young in years and spirit. Instituted in 1946, it provides engineering and scientific training in aeronautical science and technology, and in economics, work study and production at post-graduate level, so that students can eventually fill senior and responsible positions in the aircraft industry, civil aviation, the Services, education and research establishments.

The exhibits at the Open Day included instrumentation and telemetry for guided weapons and missiles, and propulsion units ranging from piston engines to rocket motors. In the department of materials, current investigations include work on fatigue sensitivity in relation to previous high-temperature creep deformation, the fatigue over-ageing of high-strength aluminium alloys and the effect of vibration during solidification of cast structures.

Of particular interest and importance is the investigation of the possible detection of fatigue damage by micro-creep measurements. These investigations, based on the original researches and theoretical studies of Prof. A. J. Kennedy, the head of the department, are now sufficiently advanced to enable fatigue damage in the metal to be detected at an early stage in its fatigue life. Thus, by applying micro-creep techniques to a component or metal it may well be possible to determine the useful and safe life for which the material may continue in service and represents a considerable advance in material technology applicable to a wide range of industries. A very general outcome of these experiments is the indication they provide that other properties (that is, other than micro-creep) may be suitably sensitive if measurements are conducted simultaneously with the fatigue stress superimposed.

Dense Ceramic

A NEW dense ceramic material has been developed as a result of research work carried out by Deutsche Steinzeugwaren of Mannheim, W. Germany. This material has a thermal expansion of 0.6 x 10^{-6} over a temperature range of 20 to 600 deg. C. This figure is very low compared to the expansion of standard stoneware which is of the order of 4 to 5 x 10^{-6}. It is, therefore, extremely resistant to thermal shock and it is expected to find uses in electrical and chemical engineering as well as many other industries.

Cadmium Plate Corroded by Resins

TESTS made by the Forest Products Research Laboratory have shown that volatile components from synthetic resin glues can be very corrosive to cadmium plate, particularly under damp conditions.

Corrosion by such components arising from wood has been studied for some time past, but the annual report of the laboratory says these studies have recently been extended to include plywood and wood glue assemblies which use various types of synthetic-resin glues.

In a series of experiments in which cadmium-plated steel samples were exposed at 48 deg. C. and 100 per cent relative humidity to the atmosphere over plywoods made from two wood species using four commercial hot-pressed plywood glues, all the plywood samples were more corrosive than the corresponding wood controls without glue. Two urea-formaldehyde (U/F) glues caused severe corrosion during a period of eight weeks, while a liquid phenol-formaldehyde (P/F) and a dry film P/F resin produced only slight corrosion.

In another series, eleven commercial cold-setting assembly glues were used with one wood. Of these, eight were U/F resins, one was a P/F, one was a resorcinol-formaldehyde (R/F) and one was a mixed syrup containing both P/F and R/F resins.

Among the U/F-glued samples, results after eight weeks' exposure varied from no corrosion to complete destruction of the cadmium plate with heavy rusting of the steel beneath. Volatile acidic substances released during the curing and ageing of the glues appeared to be the chief corrosive agents, assisted in some cases by formaldehyde liberated by decomposition of the resin.

But no generalisation seems possible as to the effect likely with any one type of resin. This is because the variation in the corrosive effect of these glues—all made from the same type of resin—seems to be due to the different hardening mechanisms favoured by makers.

IN NEXT MONTH'S ISSUE . . .

Principal features in the January issue of ENGINEERING MATERIALS AND DESIGN will include:

Special-purpose Fasteners
For load-carrying panels and blind assemblies.

Development Tests with Moly-disulphide Lubricants
Establishing optimum surface pre-treatment.

Pressure Vessel Design
A discussion on recent work in the U.K. and abroad.

Recent Applications of Laminated Plastics
Survey of present and potential applications.

Progress in Non-destructive Testing
Trends in international techniques.

Rubber as an Engineering Material
Design aspects and applications in engineering.

Corrosion Behaviour of Some Newer Metals
Titanium, zirconium, tantalum, niobium and beryllium.

Nickel Supplies

SINCE the beginning of 1958 nickel supplies have been abundant and although the International Nickel Co. of Canada Ltd. have been producing at only two-thirds maximum capacity for the last two months, nickel stocks are sufficient for well over six months' supply. It is unlikely, therefore, that the recent strike will have any measurable effect on the supplies of nickel to industry. Nickel users who have become accustomed to periodical shortages will welcome the statement by Dr. J. P. Thompson, chairman of the International Nickel Co., that in spite of labour troubles and an increasing demand for nickel which is expected in 1959, the present stocks are sufficiently large to make a shortage in the forseeable future extremely unlikely. Nearly a third of the nickel output is used for nickel-bearing stainless steels and the increasing use of these alloys throughout industry is likely to continue.

Beryllium Developments

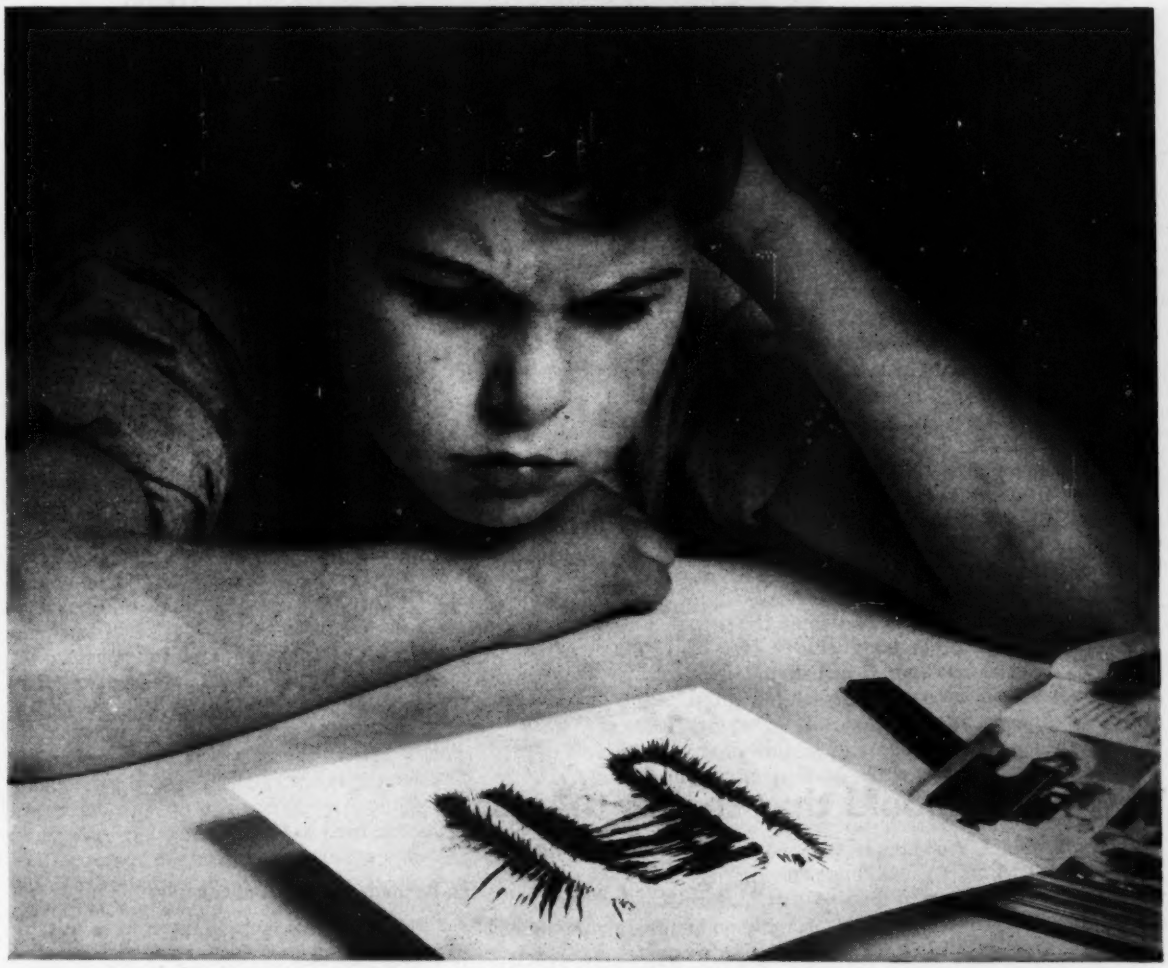
SIGNIFICANT advances in the fabrication of beryllium in the nuclear engineering industry have been made by Tube Investments Ltd. Development work has been in progress at their new beryllium laboratory and has resulted in what is believed to be the longest small bore beryllium tube yet produced. The bore is 0.3 in., the wall thickness 0.04 in. and the tube is 2-3 ft. long. A variety of other sizes of tubes have been produced up to 10 ft. long and having wall thicknesses of the order of 0.8 in. Beryllium rod and wire have also been produced and work is now in hand investigating the material properties caused by different methods of processing with a view to establishing the best production method for tubes in this metal.

News from the U.S.A. gives details of the first sheets of beryllium to be successfully rolled 12-18 in. wide and in thicknesses of 0.02-0.06 in. In order to obtain the highest strength in the resulting sheet, very accurate control is needed in the pressure on the rolls and the temperature of the metal. Ultimate tensile strength up to 104,000 p.s.i. has been obtained. Because of the metal's high toxicity the beryllium is sandwiched between two slabs of mild steel and welded all round. The whole sandwich is then rolled and subsequently the steel is peeled off.

Cheaper Vacuum Metallising

DETAILS have just been issued by the U.S. Army of the results of research into what is claimed to be an economical vacuum metallising process which can be used for coating metals as an alternative to electro-plating. Preliminary trials have shown that thin metallic films can be deposited very rapidly on glass, metals and plastics and it is expected that this process will have considerable use in industry, particularly for electrical components. Deposition of aluminium, chromium, titanium and nickel in thicknesses of 0.0001 in. have been successfully put down. The process involves the use of tungsten wire filaments but at the temperatures concerned difficulties have occurred during the production of very thick coatings with a tendency for the charge metals to alloy with the filament. Methods of overcoming these difficulties are reported to be under development.

EVERY PICTURE TELLS A **NICKEL** STORY



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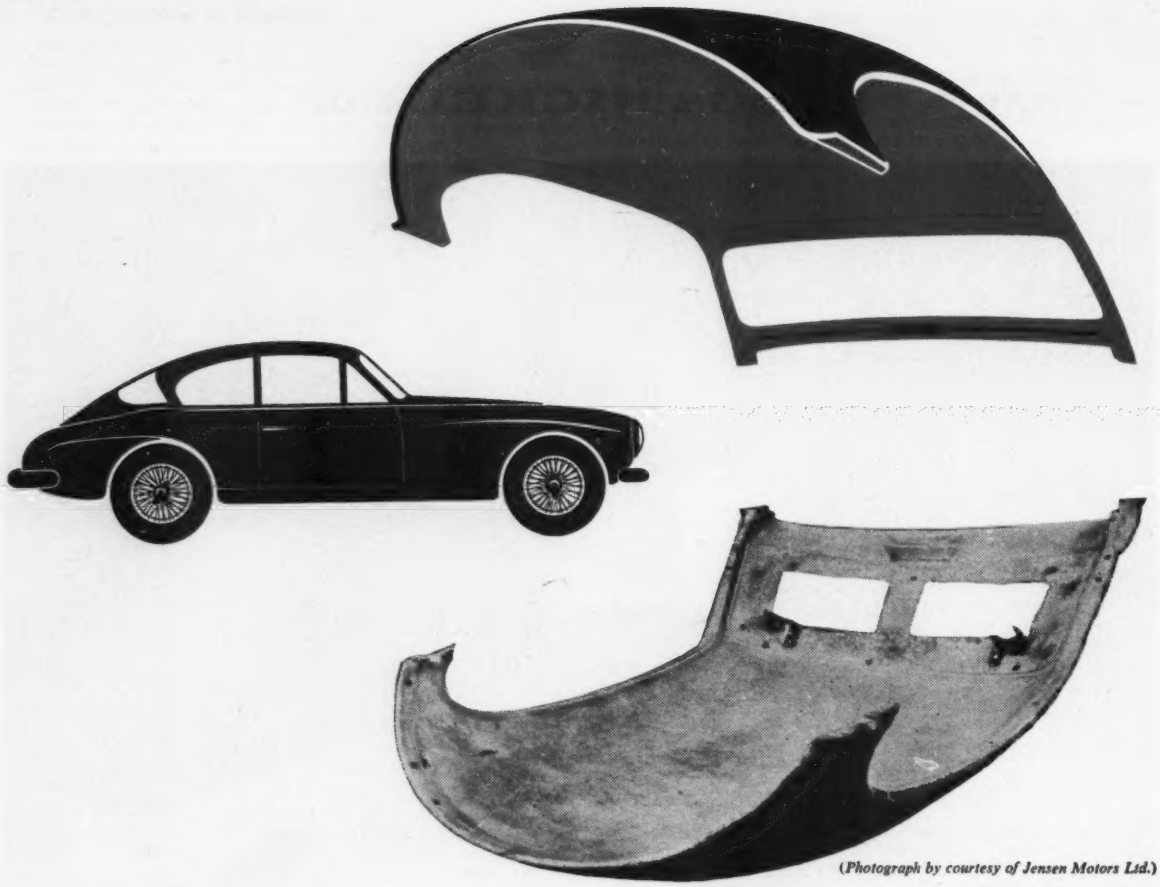

(*Photograph by courtesy of Jensen Motors Ltd.*)

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WANTED—A NEW OUTLOOK ON DESIGN

DOES the average engineering company in Great Britain spend enough on its design activities and does it treat designers as key men in its organisation? The strongly expressed view in many quarters—not only among designers—is that the answer to both these questions is "no". There are, it is true, some very bright spots—in the aircraft, automobile and electronic industries, for example—but there are also a vast number ranging in hue from pale grey to deepest black, and their existence, if it continues to go unattacked, may have very serious consequences for the country.

To emphasise the importance of this matter one cannot do better than quote Mr. F. Garner, a director of Joseph Lucas Ltd., who summed up the situation very neatly in a paper he gave a few years ago: "Managements in some industries must remember that their product designer is the most important individual in the organisation, in that if he fails there will be no business for the management to operate."

The unsatisfactory state of design can be readily appreciated if one considers the enormous attention that has been given to engineering production and productivity since the war. There has been a flood of lectures, study courses, conferences, books, pamphlets and ministerial exhortations on these subjects, accompanied by corresponding action in industry, but no one could pretend that anything like the same attention has been given to engineering design. Yet it should be obvious that unless a product is designed it cannot be produced, and unless it is well designed it cannot be sold in competition with products that are. Mr. Hugh Clausen, in his Lord Westwood Memorial Lecture before the Institution of Engineering Designers this year, put the matter admirably when he said: "The quality of an engineering product is put in on the drawing board, for although a product may be spoiled by faulty workmanship, if quality is not inherent in the drawing no other activity can make up for its absence."

Unfortunately, design, instead of being accepted as the first important link in the chain of production, is frequently regarded as a minor sideline of production and the chief designer is in many cases responsible to a production engineer or to a non-technical executive. This is a disadvantage he shares with other engineers. Dr. G. V. Lachmann, director of research, Handley Page Ltd., was recently quoted as saying that he was struck by the low status of engineers in this country compared with those on the Continent and in the U.S.A., where there are always engineers in positions of directors and vice-presidents of engineering concerns. To see how true this is, it is only necessary to examine the qualifications of directors and senior officials in our engineering industries and to observe how few technically-trained men, let alone engineers with design experience, there are in the ranks of top management.

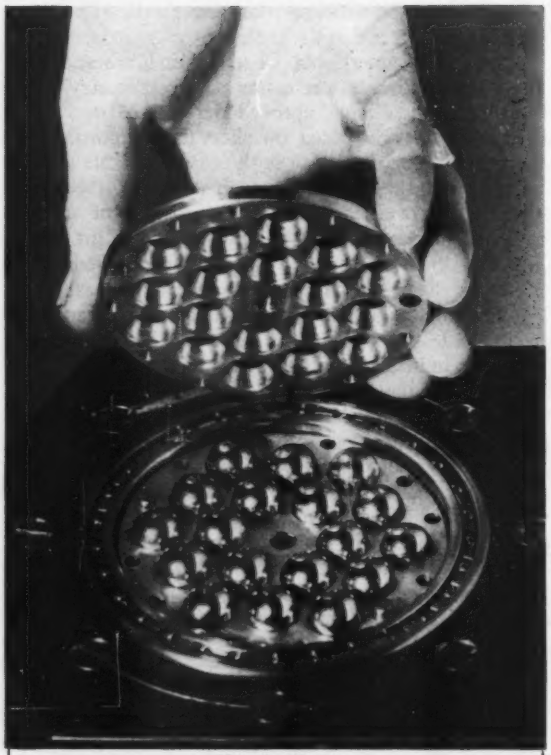
This is bad enough, but what makes it worse is that far too many firms are reluctant to invest money in the evolution of new and improved designs. All too often, directors' policy is based on short-term financial considerations, and where that is the case it is little wonder that design is neglected. To such directors, the design office is an overhead cost and in times of difficult trading conditions it may be an early target for economies, instead of receiving special encouragement to improve existing designs and produce new ones.

It is against the background of foreign competition that weaknesses in British design can best be viewed. The chief industrial design engineer of one of the great electrical groups in this country was recently quoted in an American journal as stating that Britain does not pay enough attention to design, compared with the engineering industries of other countries, and the same point was made in several passages in "Britain and Europe", the *Economist* Intelligence Unit's study of the effects on British manufacturing industry of a Free Trade Area and the Common Market. In its section on general engineering, it states: "There is a widespread feeling on the Continent that British designs are outdated, and that too little care is devoted to making them pleasing to the eye which, in certain light engineering products, can be an important selling point. . . ."

A question which arises at this point is whether, if British engineering firms decided to revitalise their ideas on design, they could find enough designers able to do the work. One result of this country's inadequate appreciation of design has been that the training of designers has not been all it should be. It is not easy to find men who have a sound knowledge of engineering principles, are capable of original thinking and can produce and understand drawings.

It is clearly time there was a reawakening, first in the attitude of management towards design and the designer, and secondly in the education of the men who must shoulder the responsibility of British engineering design in the future. Companies, trade and professional organisations, education authorities and the Government need to do some hard thinking if the engineering industry generally is to make the tremendous progress that is well within its capacity if only it overcomes its shortcomings in design.

A SURVEY OF MECHANICAL STEPLESS TRANSMISSIONS



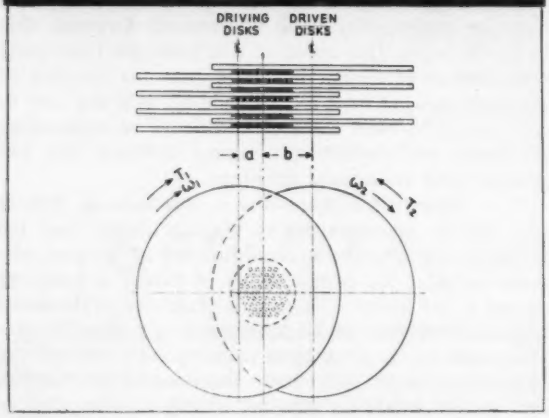


Fig. 1. Typical ball galaxy and method of multiple assembly.

Modern machines call for increasing flexibility of speed control to improve their efficiency and range of operation. This article reviews the many varieties of mechanical principle that are available to the designer

THE search for an infinite variation of output speed for a given constant input speed has resulted in a profusion of designs and ideas nearly as prolific as those relating to perpetual motion.

Because of the vast range of requirements—from heavy industrial plant to the compacted equipment used in guided missiles—variations on fundamental designs of stepless transmission units are equally large. However, for the purpose of describing their characteristics, stepless transmission units may be divided into four categories, in each of which a basically different design principle is employed: friction, mechanical (with which this article is concerned), hydraulic, electrical, and certain combinations of these four.

Below are set out the main factors which will influence the selection of a stepless transmission unit for a particular purpose, the controlling factors usually being power and torque. In applications such as computers and simulators, the controlling factor is usually the speed variation, and the power or torque is relatively unimportant. An example of this type of unit is produced by the Metron Instrument Co., and has an overall length of about 4 in.

H.P. requirement: maximum output required, and whether it should be constant or variable relative to output speed.

Torque requirement: maximum to be transmitted and the nature of its variation with speed.

Speed range: maximum and minimum speed; unidirectional or reverse speeds; limits on speed duration.

Rate of variation: uniform or non-uniform; operable when drive is stationary or in motion.

Loading: steady, pulsating, heavy or light shock loading; continuous or intermittent rating; frequency of stops and starts.

Environment: space requirements; heat dissipation; maintenance; noise level; reliability.

Most manufacturers issue literature giving suitable duty cycles for their products, but for general guidance normal duty may be regarded as 8 hr. working cycle. Where continuous duty is anticipated, or where the unit is subjected to shock loading or repeated overloading, it is advisable

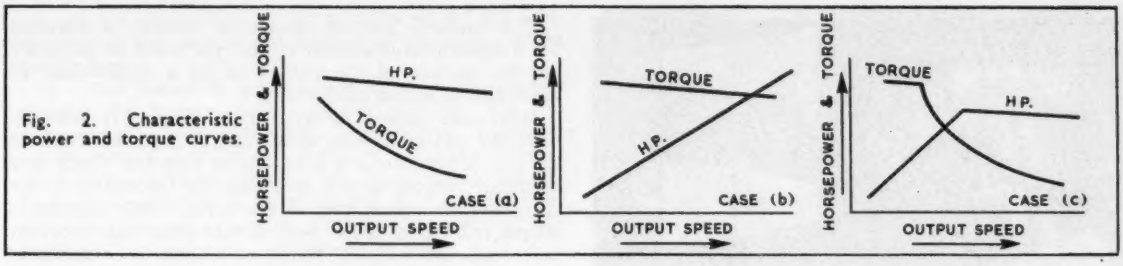


Fig. 2. Characteristic power and torque curves.

to increase the normal design loads by a factor of between 1·3 and 1·7, depending on circumstances.

For a particular loading, three general types of unit are available for use with a constant input speed:

Constant h.p. (torque varies with speed). Fig. 2, case (a).

Constant torque (h.p. varies with speed). Case (b).

Variable h.p. and variable torque (where torque and/or h.p. vary with speed). Usually associated with hydraulic units. Case (c).

Applications for the first group include conveyors, printing presses, compressors, etc.; for the second group, machine tools, such as lathes, milling machines and punch presses; and for the third group, centrifugal fans, pumps and blowers.

Most types of stepless transmission units are essentially torque convertors and, when coupled to a constant speed and power input, transmit a decreasing torque as speed increases. If the horse-power is to be constant throughout the speed range, the critical stress condition for the unit occurs at the minimum speed, where the torque is a maximum. For constant torque applications, selection should be on the basis of maximum power requirements at the maximum speed to ensure adequate torque capacity.

Where torque and horse-power are variable, the maximum power at maximum speed is the controlling condition. In this case, because of the power-speed relationship, the capacity of the unit at lower speed will be far in excess of requirements.

An infinitely variable speed gear should be selected so that the maximum speed of the driven shaft corresponds to the maximum speed of the input shaft, i.e., it should not be used as a speed reducer to give a continuous reduction in output speed.

The rate of change of speed, and whether it is uniform or not, is primarily determined by the application of the infinitely variable speed unit. The majority of self-contained units are provided with a means of selecting different ratios by either manual or mechanical operation; the latter may be related to the demands and the selection thus made automatic.

The type of loading is an important factor. Where a mechanical unit is envisaged, the applied loads must be as smooth as possible, as shock loads may otherwise accelerate wear and distortion. Electro-magnetic couplings are probably the most flexible, followed by friction drives and hydraulic units.

When selecting a particular unit, temperature environment must not be neglected. The heat generated can be considerable, although most units are designed to dissipate it readily, but if the ambient working temperature is much above room temperature, due thought must be given to adequate cooling.

Friction Drives

The many types of friction drive for infinitely variable speeds may be grouped into those which employ special material for the friction surfaces (such as leather belting, asbestos compounds, etc.) and those which have metal-to-metal contact, usually in the presence of a lubricant. The former tend to be installed as an integral part of the design, while the latter are more often available as drive units. Some of each type are shown diagrammatically in Fig. 3.

In general, it is desirable to keep the input and output drive centres constant irrespective of speed and power

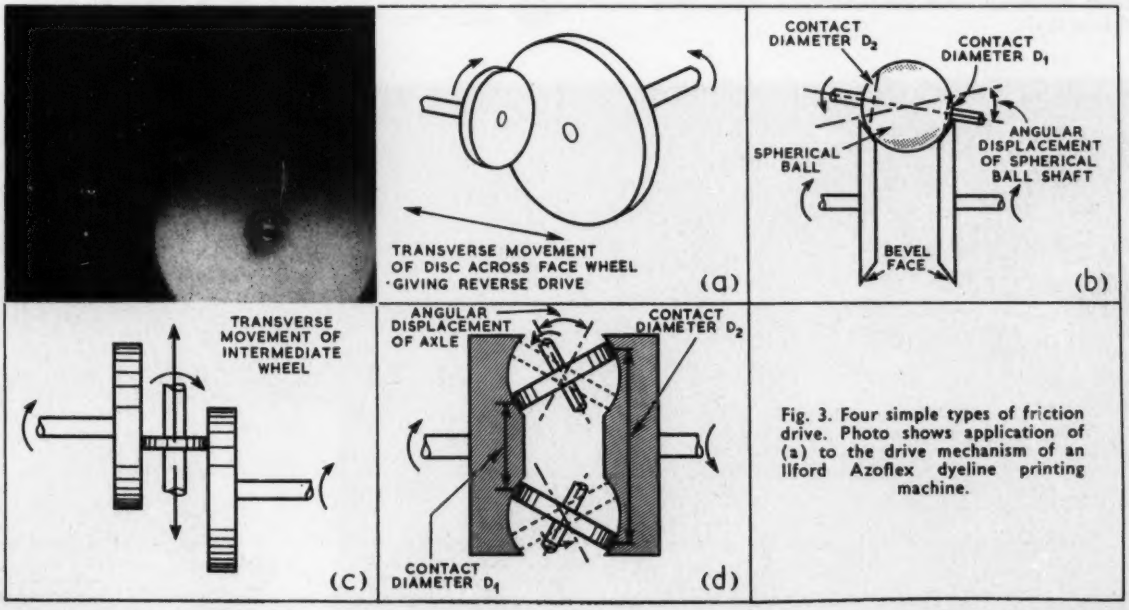


Fig. 3. Four simple types of friction drive. Photo shows application of (a) to the drive mechanism of an Ilford Azoflex dyeline printing machine.

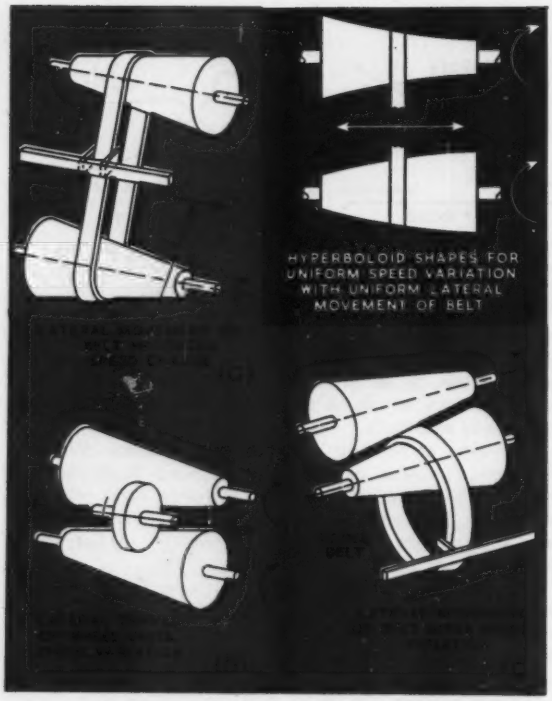


Fig. 4. Speed variation using cone pulleys.

alterations, although the physical movement of one of the shafts may obviously be desirable in certain applications.

DRIVES USING FRICTION MATERIAL—The simplest of all such drives is the cone-pulley type, of which there are several variations. Each of the three shown in Fig 4 has the same characteristic, i.e., the torque output is inversely proportional to the speed and, except for the variation at (c), both driver and driven shaft have the same direction of rotation.

Although not obvious, the rate of change in rotational speed of the driven shaft is not a linear function of the belt displacement, so equal increases in the belt displacement do not produce equal changes in the speed of the driven shaft.

If a uniform rate of change of rotation is required for a uniform displacement of the belt, it will be necessary for the surface of the pulleys to be a hyperboloid of revolution as shown inset in Fig. 4.

With cone pulleys of either type, slipping is inherent, since the contact surface speed varies across the width of the belt. Therefore, it is necessary to keep this width to a minimum, which, in turn, will limit the amount of power that may be transmitted. These types, while offering a simple solution to speed control, may necessitate frequent belt replacements; the ratios obtainable are obviously limited by pulley length and the smallest diameter from which the belt will transmit the required power.

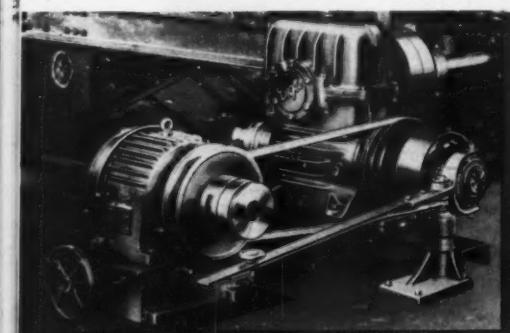
Variable-pitch pulleys overcome these disadvantages by adjusting the width between the conical faces of the pulley, thus allowing the belt, which transmits power from its side faces, to be adjusted to a different pitch diameter.

The majority of this type may be adjusted while in motion, but, as they usually need daily pulley adjustment through the entire range to ensure complete freedom of moving parts, it is advisable to use a type that is adjustable only when stationary, if merely a correction to speed is required and the ratio is to remain constant thereafter.

Again, the ratios are infinitely variable only between the limitations set by the pulley diameters. Where both cheeks of the pulley move simultaneously in relation to the belt centre line, no undue scuffing of the belt would be expected. In designs where only one cheek of the pulley moves, the belt will be off-centre relative to the other pulley, unless this, too, has an adjustable cheek. Where only one pulley is adjustable, then there is obviously a limitation on minimum pulley centres; the greater their distance apart, the smaller will be the angle of the belt to the pulleys.

Again, with this type of transmission, unless both pulleys are adjustable simultaneously, then some method of re-adjusting pulley centres will have to be incorporated. In a number of designs, the mechanisms for adjusting the cheeks of a single pulley also incorporate a means of moving the pulley centre and, as this pulley is usually the driver, the prime mover can be moved on its base to maintain belt tension.

To overcome the misalignment when only one pulley cheek is moved, the motor may be angularly displaced relative to its base, as shown diagrammatically in Fig. 5. Where the pulley cheeks are spring loaded to maintain belt contact, then the adjustment is to the motor, and the



belt accommodates itself to the diameter set by the combination of belt tension and stiffness of the spring in the pulley cheek.

In certain instances, it is possible to use a countershaft between the driving motor and the machine. For this combination a unit comprising two pulleys, adjustable simultaneously, provides the means of obtaining different speed ratios without affecting the main pulley centres. Such an arrangement is shown in Fig. 6. These units are available for a wide range of powers and speeds and may employ either single or multiple-belt drives.

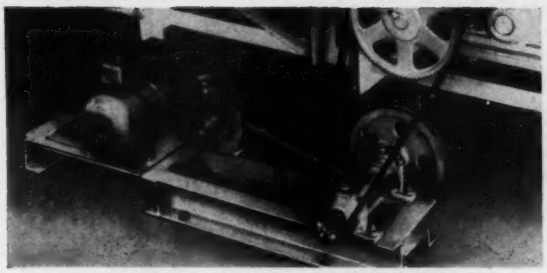


Photo: Crofts (Engineers) Ltd.

Fig. 6. Speed adjustment using countershaft.

Johnson Adjustable Pulley

An interesting adjustable pulley for speed correction is the Johnson pulley which employs a constant diameter sheave designed to take either the standard truncated V-section belting or flat belts. In this design the adjustment of the pulley cheeks causes, by virtue of the belt tension, the non-metallic sheave to move off-centre in relation to the main pulley, the drive being transmitted by frictional contact between the part of the sheave remaining within the pulley cheeks.

Where the drive is transmitted by the friction between the side faces of the belt and the pulley cheeks, the design of the belt itself is of great importance, since too large an area of contact will result in a high degree of scuffing, and too small an area will not permit the transfer of high powers.

To reduce the amount of scuffing, belts consisting of a number of pads have been designed. A typical example is shown in Fig. 8 and it is usual to find this type incorporated into a self-contained unit of the type shown.

To some degree, slip is inherent in all belt drives, and to eliminate it a special belt using linked pads has been designed to give 100 per cent positive drive (see Fig. 9). Each pad is composed of a number of closely-fitting laminations which project through the side of the links and mesh in radial teeth cut into the adjustable cheeks of the pulleys. Each cheek is so positioned on the shaft that the projecting teeth on one cheek correspond to the valley between two teeth on the other cheek. Up to 20 h.p. may be transmitted with this type with an overall speed ratio of 6:1. The whole assembly may be enclosed and run in an oil bath, as all the contacting parts are metallic.

While it may be thought that many of these methods of transmission are perhaps of crude design, they are nevertheless in constant use, sometimes in the most appalling conditions, and show a very high degree of reliability in the face of very limited maintenance.

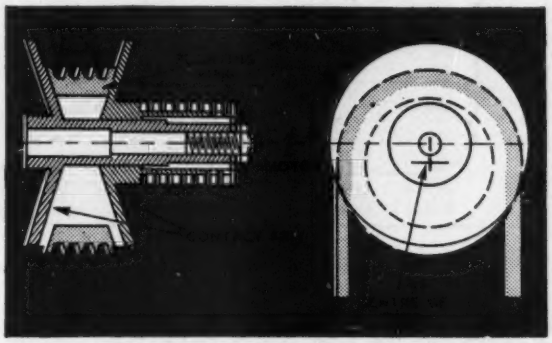


Fig. 7. Floating ring in Johnson variable-speed pulley.

In the Prym gear the basic principle of a rimmed wheel in contact with a conical face disc is used. The cage containing two discs and the pressure loading device is drawn across the input and output discs, thus varying the speed ratio. The cage is eccentric to the input and output shafts and is rotated by means of a worm engaging with teeth cut on the periphery of the cage. The two centre discs are carried on hollow spindles, which engage with a spindle provided with a left- and right-hand helix. Initial contact pressure is by a spring bearing on these discs, and when the drive is started the spindle will travel, due to its helix, until it provides additional pressure, according to the

Fig. 8. Self-contained variable-speed unit using linked belt (shown above).
Photo: Reiter & Co.

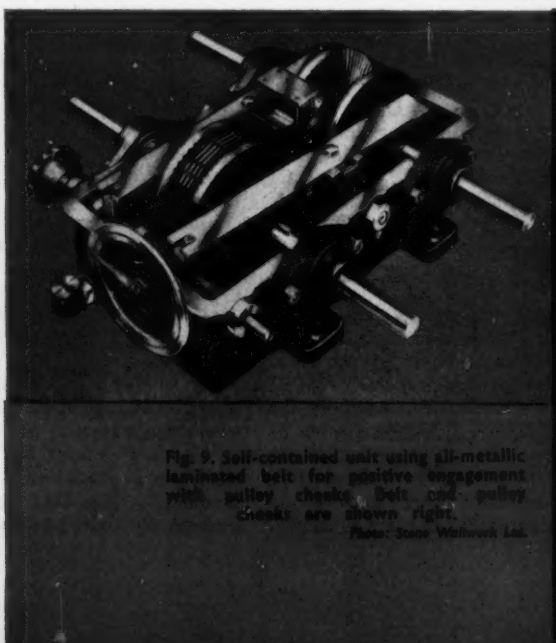
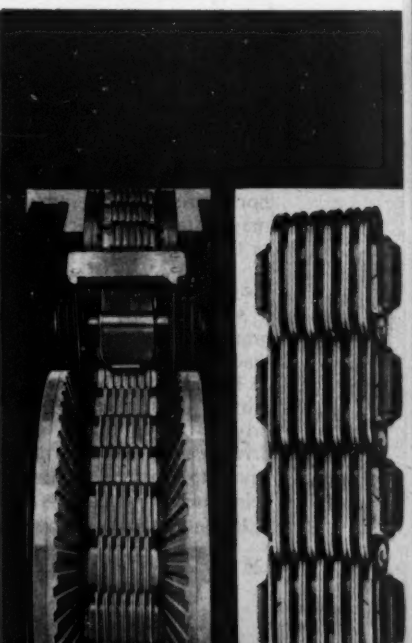
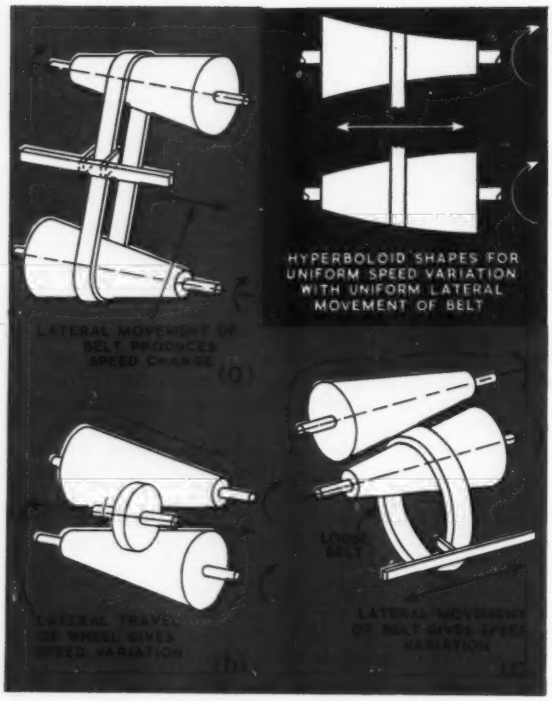


Fig. 9. Self-contained unit using all-metallic laminated belt for positive engagement with pulley cheeks. Belt and pulley cheeks are shown right.
Photo: Stone Wallwork Ltd.




HYPERBOLOID SHAPES FOR UNIFORM SPEED VARIATION WITH UNIFORM LATERAL MOVEMENT OF BELT
LATERAL MOVEMENT OF BELT PRODUCES SPEED CHANGE
(a)
LOOSE BELT
LATERAL TRAVEL OF WHEEL GIVES SPEED VARIATION
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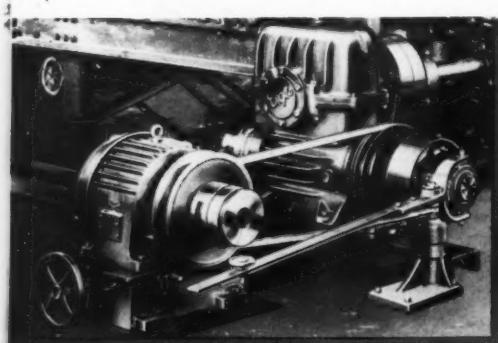

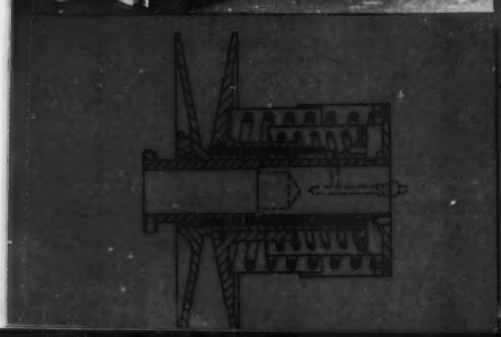

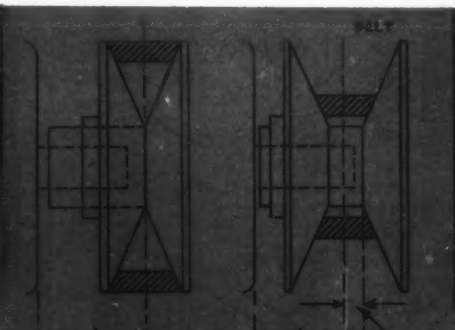

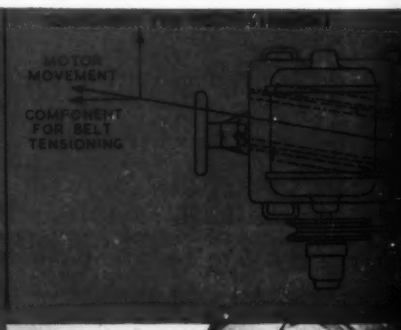

Fig. 5. (*Above left*) Application of adjustable pulleys by Crofts (Engineers) Ltd. (*Left*) Spring-loaded adjustable pulley cheeks. (*Above*) Belt displacement by movement of one pulley cheek. (*Above right*) Simultaneous belt adjustment and tensioning. (*Right*) Further means of belt alignment and tensioning by Industrial Drives Ltd.

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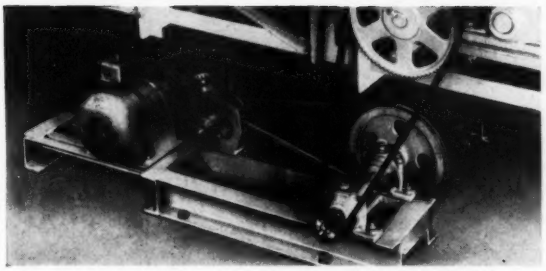

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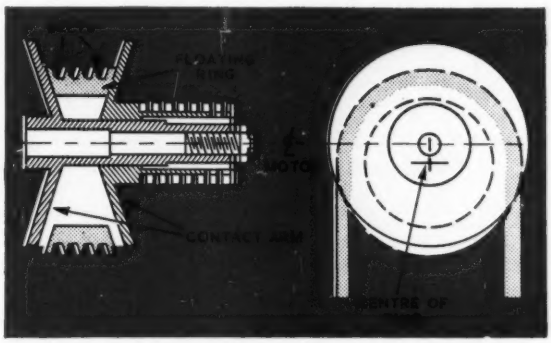

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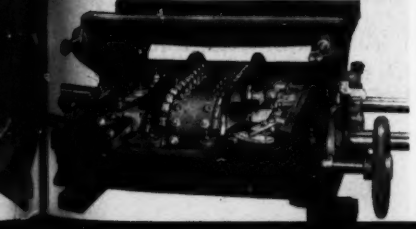
Photo: Barker & Co.



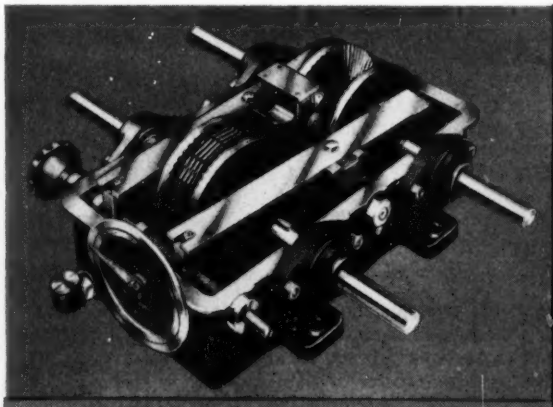
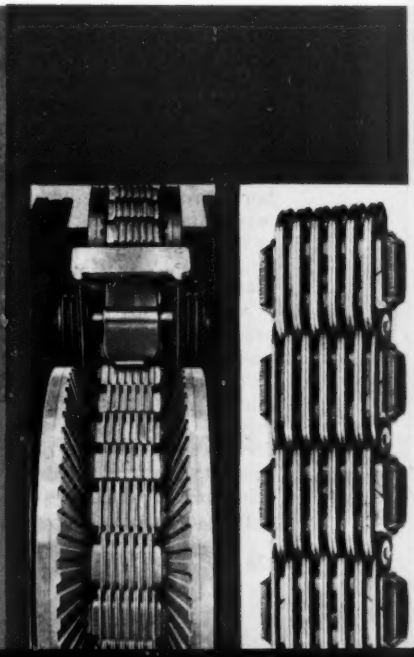


Fig. 9. Self-contained unit using all-metallic laminated belt for positive engagement with pulley cheeks. Belt and pulley cheeks are shown right.
Photo: Stone Wallwork Ltd.



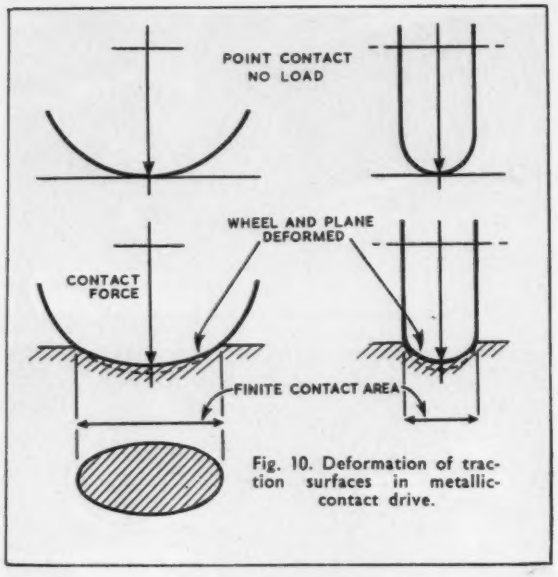


Fig. 10. Deformation of traction surfaces in metallic-contact drive.

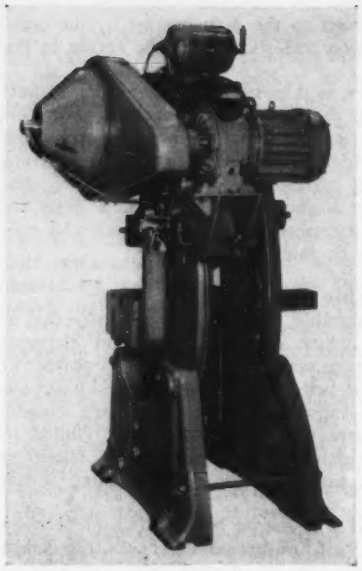


Fig. 11. Kopp variator fitted to rear of Hordern, Mason & Edwards press.

torque, on the discs through the medium of a series of Belville washers. Several sizes of this drive are available up to 10 h.p., with ratios varying up to 10 : 1.

METALLIC CONTACT FRICTION DRIVE—The principle of an all-metal traction drive is one of the oldest, yet it is only recently that this type has become available as self-contained units. The simplest example of it is the locomotive driving-wheel; from the diagram it will be seen that under conditions of no-load the contact area is virtually infinitesimal. When, however, load is applied, deflections in both surfaces take place, with the result that a contact area of finite dimensions is established, and a drive becomes possible. The torque transmitted depends upon the coefficient of friction, which is determined by the material and, when present, the characteristics of the lubricant. These characteristics depend upon the physical composition of the lubricant and upon its viscosity, the latter having a profound influence, for, when deformation of the surfaces takes place, the oil is squeezed out.

The resulting dryness depends on the time available for squeezing, which is a direct function of the speed of rotation. At speeds below 200 r.p.m., this coefficient is not greatly affected by viscosity, but about this speed the value drops rapidly with higher viscosity.

Ultimate failure of this drive is usually due to metal fatigue caused by repeated stress reversals. Up to the slip point, in the absence of dirt, the slippage is negligible, but at the slip point it is intermittent, rapidly increasing until final disintegration of the surfaces. Surface wear under normal running conditions is negligible, and the useful life may be taken as function of the number of stress reversals or the speed of the unit.

Kopp Speed Variator

An interesting development of the principle shown diagrammatically at (b) in Fig. 3 is the Kopp variator. This is made in eight sizes to accommodate input powers up to 15 h.p. at 1,440 r.p.m. with developments capable of transmitting up to 100 h.p. In the mechanical assembly the drive is transmitted by means of two cones and a series of drive balls; when the diameters D_1 and D_2 (Fig. 3) are equal, the surface speeds on the part of the ball which is being used are equal and the input and output shafts rotate at the same speed. If, however, the balls are tilted as shown, D_1 is less than D_2 and, as the input drive shaft is rotating at a constant speed, a point on the ball at D_1 is moving slower than a point D_2 on the surface of the variator; in the position shown a speed increase results at the output shaft. The balls, which can be rotated in either direction by means of spindles passing through an iris plate, give an overall ratio of 9:1, that is, one-third of the input speed to three times the input speed.

An essential part of the variator is the device for applying pressure to the balls. On the end of each drive shaft is a disc which is splined to the shaft. The drive cone is a loose fit on the end of the drive shaft and the power is transmitted to the cone, and hence to the ball, by a clutch device consisting of a series of ramps in the splined discs and cone faces into which rollers are fitted. Springs are used to exert pressure between the cones and drive balls in the "no-load" position, the rollers being at the bottom of the ramps. Under loading, the splined disc tends to advance towards the cone; the rollers ride up the ramps and convert the driving torque into a lateral thrust, so that the greater the applied torque the greater the pressure exerted by the cone against the balls.

Point contact in theory does not exist under practical conditions and, as previously explained, the applied load deforms the contacting surfaces to produce a finite area, the magnitude of which governs the power transmitted. This finite area for a given power transmission may be obtained by either high loading of a single contact or, alternatively, by a lower loading and multiple contact faces.

This latter arrangement is one employed in a unit invented by W. S. Rouverol of the University of California. As seen in Fig. 1, a range of balls (each free to rotate in any plane) is sandwiched between a driving and driven disc. Each ball moves at a constant speed in a circular orbit about the centre of the cage and, in addition, has a superimposed spinning motion that permits it to roll without slipping on the faces of both discs. The axis of rotation of the cage must intersect the disc faces at a point where the velocities of the discs are equal and opposite. By laterally shifting the cage, or one or both discs, the ratio a:b is altered and with it the output speed. It is of interest to note that not all the power is transmitted through the balls from one disc to the other, but part is

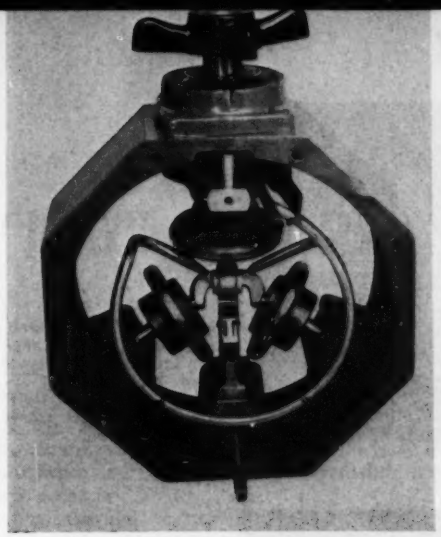


Fig. 12. Sadivar 53 unit dismantled to show main body of mechanism.

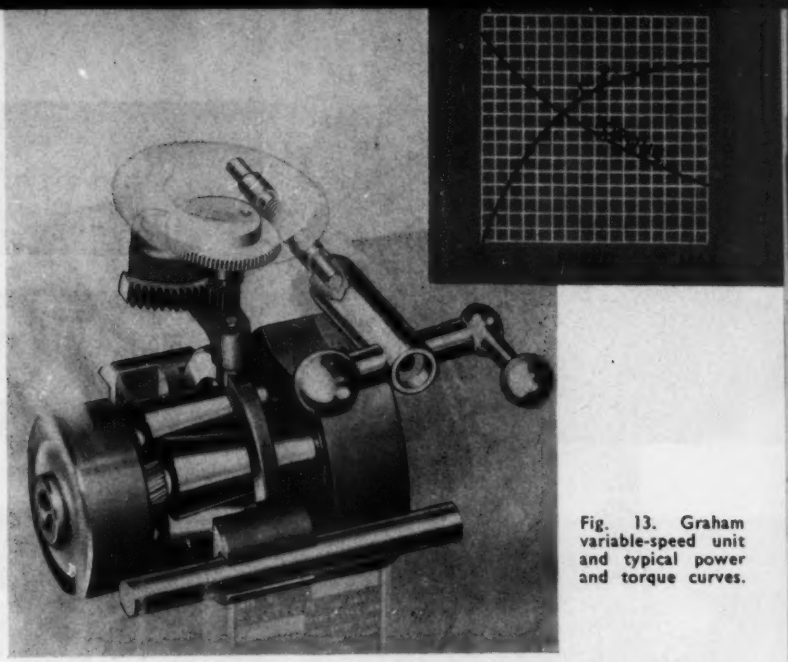


Fig. 13. Graham variable-speed unit and typical power and torque curves.

transmitted through the cage. For each ball with a component of translation in the direction of its tractive force, there is a ball on the opposite side of the cage with an equal component directed opposite to the tractive forces, so that the work being done on the cage by the balls in one half of it is being delivered back to other balls in the opposite half of the cage, and from these balls to the driven disc.

Applications of this drive are at present undergoing development in motor-car transmissions. Other uses for it would be machine tools, cooling equipment and aerial cameras.

The Sadivar 53 is an example of a constant horse-power unit employing three rollers, capable of angular displacement, fitted between an input and output disc—as shown above in Fig. 12. To reduce wear and frictional losses, a torque loading device is used to increase the pressure on the rollers as the output torque increases. This particular unit is capable of handling up to 5 h.p., giving an infinitely variable speed output ranging from 450 to 3,150 r.p.m. for an input speed of 1,500 r.p.m.

An example of metallic traction of a different principle is employed in the Graham variable speed units which are manufactured in various sizes to handle up to 15 h.p. In this drive a cage containing one end of a set of three tapered rollers is coupled to the input shaft. The other end of the rollers carries a pinion which meshes with the ring gear on the output shaft. The rollers are rotated by contact with the traction ring which imparts to the rollers a speed proportional to its linear travel. Apart from the initial load, the traction pressure is obtained by the centrifugal force of the rollers which press out on the ring.

A unique development from the design where a wheel moves across the face of a second wheel, each axis being at right angles to each other, is shown in the F.U. variable speed unit. In the smaller model for ratings up to 3·4 h.p.

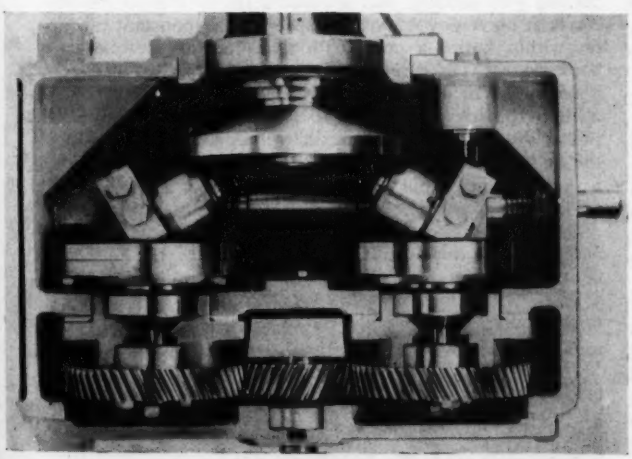


Fig. 14. Showing the rollers and face plates of the F.U. co-axial transmission unit.

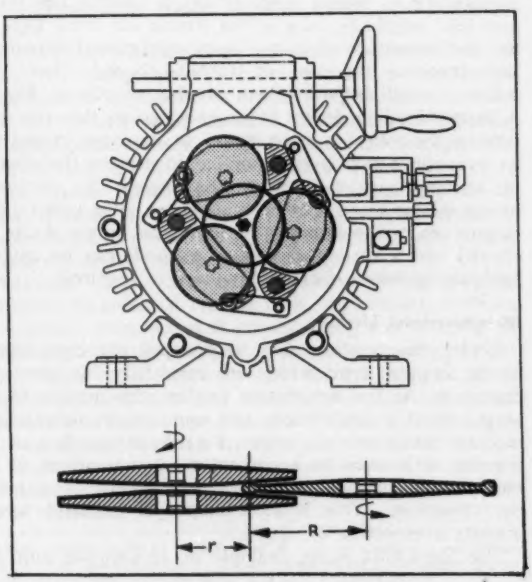


Fig. 15. Beier speed variator showing arrangement of multiple discs.

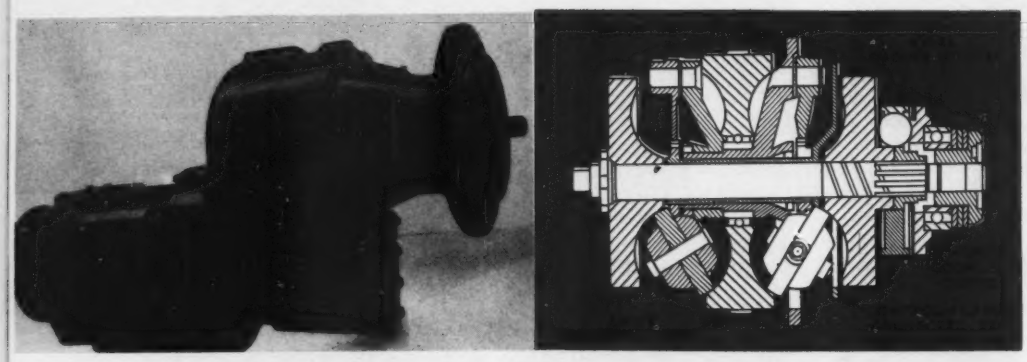


Fig. 16. (*Far left*) Unit designed by Tiltman Langley Ltd. for constant-speed output with 30-kVA alternator. (*Left*) Principle of Hayes transmission.

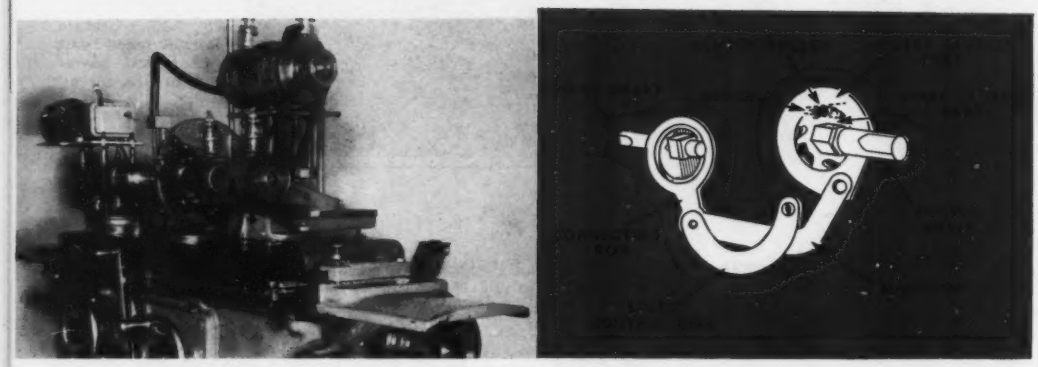


Fig. 17. Single unit of Zero-Max impulse unit and typical application to grinding machine.

a single roller is used, the input shaft being offset to the output shaft. In the larger models of up to 17 h.p. the input and output shafts are coaxial. As with the majority of the units, pressure on the rollers is varied proportionally to the torque. With this type of unit the contact between rollers and face plate is normally line contact.

In general, it is usual to use speed variation units for a varying output from a constant speed input. In certain spheres of engineering, however, it is possible that a constant speed output is required from a varying input. This has been developed by Tiltman Langley Ltd. for aircraft use where an a.c. alternator is required to operate at a constant r.p.m. over a range of engine speeds. The Hayes principle, originally used in the Austin car from 1934-38, has the advantage of many years' operational experience and involves the use of toroidal-shaped discs with rollers loaded between them similar to (d) in Fig. 3. A torque loading device is incorporated so that the pressure on the rollers is proportional to the input torque and an over-run clutch is incorporated to prevent the alternator driving back through to the engine. An overspeed device is also fitted. For constant or variable speed applications other than aircraft, the input and output shafts are coaxial and a variety of control methods can be applied, particularly where full automaticity is required.

Mechanical Units

Under this heading may be grouped the class known as the impulse type, which are essentially for low-speed operation. As the description implies, the motion to the output shaft is intermittent and some inertia balancing is required for a smooth output. To reduce the effect of the impulse, it is usual to group several combinations of the mechanisms, thereby increasing the number of impulses per revolution. This is an example of constant torque output, irrespective of speed.

The Zero-Max is an example of an impulse unit and is available in various sizes suitable for constant output torques varying from 10-100 in. lb. at speeds adjustable between zero and 400 r.p.m. for an input speed of 1,800 r.p.m. Fig. 17 illustrates the principle involved. At zero output speed the main link swings about its pivot. As the control is moved, the connecting rod is tilted, thus imparting a reciprocal movement to the pivot which, by the unidirectional clutch, drives the output shaft.

The Beier stepless speed variator transmits torque by utilising the drag force of an oil film interposed between driving and driven members—thus avoiding metallic contact. The Beier gear is available in sizes suitable for transmitting ½ to 300 h.p. and is constructed to transmit either constant horse-power over the speed range, constant torque or, within limits, a combination of constant torque and horse-power. Three sets of discs are sandwiched between a similar set of discs on the input shaft. The drive is transmitted from the input shaft to the three sets of discs and thence via gearing to the coaxial output shaft. By adjusting the depth of contact R (Fig. 15) of the three sets of discs, a variation in output speed is attained.

According to the disposition of the rimmed and plain discs, constant horse-power or constant torque may be achieved. As shown in Fig. 15, the discs are arranged for constant horse-power output; by changing the positions so that the rimmed discs are on the input shaft, constant torque may be obtained.

MANUFACTURERS AND AGENTS

Variable-pitch Pulleys and Units
Almco Supersheen
Barker & Co.
Crofts (Engineers) Ltd.
J. H. Fenner & Co. Ltd.
B.G. (London) Ltd (G.I.B.)
Industrial Drives Ltd.
L. J. Gear Co. Ltd (Johnson)
Henry Lindsay Ltd.
Northern Manufacturing Co. Ltd.
Peter Rayner Ltd.
Stone Wallwork Ltd. (P.I.V.)
Frank Wigglesworth & Co. Ltd.
Williams & Womersley Ltd.
Motor Gear & Eng. Co. (Prym).

Metallic-contact Friction Drive Units
Allspeeds Ltd. (Kopp).
F.U. (London) Ltd.
Graham Transmissions Inc., U.S.A.
Sadi Engineering Ltd. (Sadivar 53)
J. Stone & Co. Ltd. (Hayes).
Tiltman Langley Ltd. (Hayes).
Metron Instrument Co.

Mechanical Units
Armstrong Whitworth (Metal Industries) Ltd. (Beier)
V. A. Howe & Co. Ltd. (Zero-Max.)

"NEW" MATERIALS FOR NUCLEAR ENGINEERING*

THE selection of materials for use in nuclear engineering is governed by service conditions of stress, temperature and environment. Additionally, their nuclear properties and behaviour under irradiation must be taken into account.

For thermal reactor applications, the capture cross-section (the ability to capture neutrons and so prevent their being available for fission) tends to limit the choice to aluminium, magnesium, zirconium and beryllium. Materials of higher capture cross-section such as stainless steel are not precluded if they can give equivalent containment in very thin sections. For reactors in which enriched fuel can economically be used, the refractory metals, niobium, vanadium, tantalum, etc., can be considered.

A first selection of canning materials can be made on neutron absorption data but, additionally, there must be no reaction with fuel, coolant or moderator; the latter criterion restricts the application of steels and allied metals because of their reaction with uranium at a temperature of approximately 700 deg. C. to form a liquid alloy.

BERYLLIUM—The difficulties experienced in the fabrication of beryllium have been attributed to both its crystal structure and the effect of impurity content. Powder metallurgy techniques are generally used, but further treatment of the reduced metal is required to attain powder in a suitable state of purity and size for sintering. The strength of beryllium is fairly high, but after mechanical working its ductility shows marked anisotropic behaviour. The toxicity of the metal and its compounds further increases the difficulties of its development.

ZIRCONIUM—Zirconium has excellent fabrication characteristics and good mechanical properties at moderate temperatures; it possesses considerably greater strength than the immediate alternative of magnesium alloys and is valuable as a stress-bearing member at temperatures up to 500 deg. C. The outstanding feature of the pure metal is its aqueous corrosion resistance.

NIOBIUM—The demand for a high-temperature canning material led to the selection of niobium. It possesses a high melting point (approx. 2,470 deg. C.), suitable physical and mechanical properties, and does not react with uranium. As with other canning materials described, the extraction process is complex in comparison with the more conventional materials and is relatively costly. Tantalum is invariably associated with niobium; a parallel may be drawn with hafnium and zirconium, although their capture cross-section is not so high and thus its removal to very low levels not so necessary. The metal readily absorbs nitrogen and oxygen at temperatures greater than 500 deg. C., resulting in a brittle product which is difficult to fabricate.

Beryllium being machined on a lathe enclosed in a ventilated cabinet in the laboratory specially designed and built for research work on beryllium by G.E.C. at Erith.

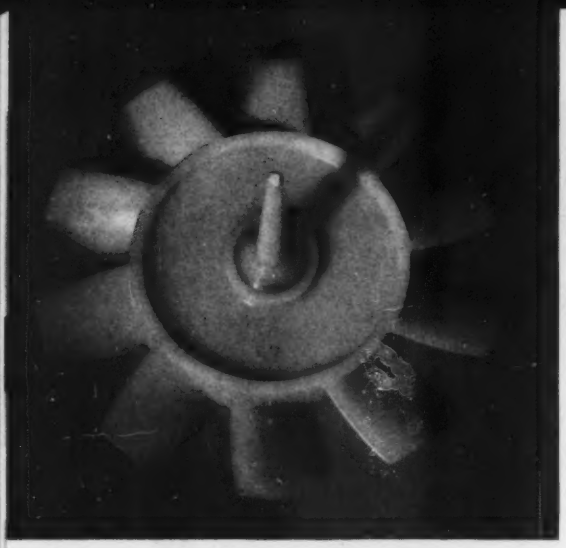
Sectioned model of a G.E.C. fuel element for Hunterston nuclear generating station, showing the graphite sleeve, the finned fuel-can of magnesium alloy, the natural uranium fuel rod and the Sintox beam which supports the cartridge inside the sleeve.

STRUCTURAL MATERIALS—These may be classified as beyond the nuclear core of the reactor and not subjected to appreciable intensities of irradiation; selection can be made from conventional materials. The effect of irradiation is to cause embrittlement, which increases the susceptibility of carbon and low-alloy steels to brittle fracture.

High reactor outlet temperatures necessitate the use of high-alloy steels of the stainless or heat-resisting types: a suitable range of steels exists, but problems of fabrication of large structures may be introduced.

CERAMICS—There are many ceramics which present themselves as potential reactor fuels, e.g., oxides, carbides and silicides. Attention is at present being concentrated on the development of uranium oxide. Its technology is far from straightforward; it can exist under a wide range of compositions, and factors of variable grain size and sintering conditions add to the difficulties. These variables may have significant effect on its behaviour under irradiation and much still remains to be done to elucidate this. In particular, an extensive programme of testing under irradiation is necessary.

** These extracts are from a paper read at a recent conference on nuclear energy held by the Federation of British Industris, by L. Grainger, deputy director, research and development, U.K.A.E.A. industrial group.*



Fan rotor for commercial engine made by Resinoid & Mica Products Ltd.

Heavy-duty high-speed counter by English Numbering Machines Ltd., with figure wheels and transfer pinions made from Maranyl nylon compound.

NYLON IN MECHANICAL ENGINEERING

The term nylon embraces a family of related polymers having similar basic properties. This article examines some of them and shows particularly how nylon can be used for gears and bearings

by J. L. RILEY*

ALTHOUGH best known by its use as a textile fibre, nylon in its solid form has in recent years aroused increasing interest as a strong, durable material for the manufacture of mechanical parts, particularly gears and bearings. In this form, its tensile strength and rigidity are admittedly lower than those of metals (see Table 1), but its inherent qualities of resilience, self-lubrication and corrosion resistance enable advantageous results to be obtained under suitably chosen conditions.

Considerable savings in cost are also often possible. This arises because nylon parts, even those of considerable complexity, can be produced simply and rapidly by the injection moulding process, commonly used with other thermoplastics materials, such as polystyrene and polyethylene. Even on a raw material basis, nylon is cheaper volume-for-volume than the more expensive metals such as copper and brass (see Table 1).

CHEMICAL NATURE AND TERMINOLOGY—Nylon is a synthetic organic polymer, i.e., its fundamental structure is that of very long molecular chains built up during the manufacturing process by linking together smaller organic molecules. It falls into the general category of thermoplastics materials in that it can be moulded, without being affected chemically, under the influence of heat, and in this general sense resembles polyethylene. Unlike polyethylene, however, nylon is not the name of one individual substance, but of a whole family of related materials, all having similar basic properties, but differing in certain details. In actual fact, though, only four nylons are available commercially at the present time, namely, those identified chemically by the nomenclature 66, 6, 610 and 11. Table 2 lists the trade names under which these various types are sold and indicates the significant property differences.

Type 66 nylon is the one most commonly used for mechanical parts in this country and the U.S.A., and subsequent use of the term "nylon" can be taken as referring specifically to this type, unless stated otherwise.

ADVANTAGES AND APPLICATIONS—In an initial assessment of suitability or otherwise for a specific application, the following factors are worthy of consideration:

Nylon is a self-lubricating material and can operate successfully in many conditions where metals would fail unless lubricated continuously. This is particularly advantageous where the presence of oils or greases is undesirable (e.g., food equipment and textile machinery) or with components where lubrication is inconvenient (e.g., certain automobile parts). It should not be inferred from this that conventional lubricants cannot be used with nylon parts; in fact, where their use is possible greatly enhanced performance will normally result. Internal lubricants such as graphite or molybdenum disulphide, which by simple methods can be blended into the nylon moulding powder prior to fabrication, are similarly effective. If there is no problem of corrosion of adjacent metal pieces, water can be used as a lubricant.

Nylon parts are less noisy than comparable metal ones. This property is a significant advantage in such applications as curtain runners, desk drawer rollers, office duplicating machine parts and cine camera and projector gears. Under some circumstances, dry nylon parts "squeak" when moving in contact with metal, though this can be eliminated by an external or internal lubricant, such as graphite or aluminium stearate filler.

The low density of the material gives rise to important weight savings in some applications. Thus, conveyor belts made up from moulded nylon slats are very light, and require relatively little power to operate them. Similarly, nylon chains are suitable for low intertia drives in instruments.

* *Technical service and development department, I.C.I. Plastics Division.*

TABLE 1. Comparative properties and cost of type 66 nylon and metals

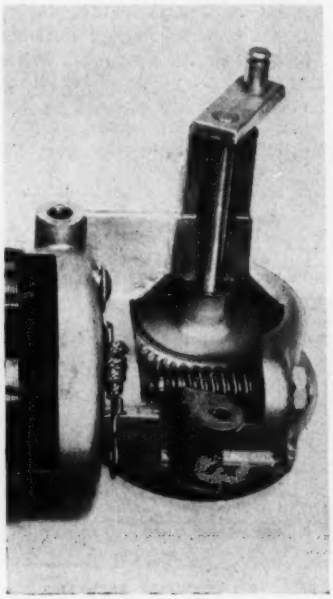
Material	Tensile Strength p.s.i.	Young's Modulus p.s.i.	Density gm./c.c.	Melting Point °C.	Coeff. Linear Thermal Expansion °F. × 10⁻⁵	Cost d./lb.	Relative Cost per unit vol.
Nylon (dry)	11,500	$4{\cdot}3 \times 10^5$	1·14	264	5·5	93	100
Cast Iron	16,000	$14–23 \times 10^6$	7·2	1100–1200	0·6	2·1	14
Steel (unhardened)	60,000–100,000	$30–36 \times 10^6$	7·8	—	—	—	
Copper (cast)	19,000	—	8·9	1080	0·9	20	165
Copper (wrought)	34,000	16×10^6	8·9	—	—	—	
Brass (cast)	18,000	9×10^6	8·6	895	1·0	18	145
Phosphor Bronze	58,000	$13{\cdot}5 \times 10^6$	8·9	—	—	—	
Aluminium (cast)	19,000	$10{\cdot}3 \times 10^6$	2·7	660	1·2	21	54
Polyethylene	1,500	—	0·92	111	16	34	30

Nylon is corrosion resistant over a wide range of conditions and can be used in contact with most oils, fuels and organic solvents. Alkalis and mild acids do not attack it, nor is it affected by sea water. It cannot, however, be used in contact with strong acids or strongly oxidising chemicals such as hydrogen peroxide.

Nylon parts can be decorative as well as functional without recourse to relatively expensive finishing treatments such as chromium plating, which is often used with die-cast metal parts. If required, mouldings can be produced in a range of attractive colours at little additional cost, simply by incorporating suitable pigments prior to moulding. Good examples of the use of nylon in this way are soda syphon tops, refrigerator and washing-machine parts and motor-car accessories. Coloured domestic water taps and even kitchen sink units have been moulded on the Continent.

Moving nylon parts are not harmed by dirt and grit in the same way as metal ones. The particles are absorbed into the relatively soft resilient surfaces and the components continue to function perfectly satisfactorily. This is a particularly useful property for, say, bushes which are to be used in dusty environments (for example, in mine and quarry equipment).

MACHINING—Although injection moulding is the cheapest way of preparing large numbers of components, it is often convenient to obtain prototypes or small production quantities by machining from the extruded rod or tubular bar, available commercially in a range of sizes. In general, machining of nylon presents no difficulties and the methods used are similar to those of free-cutting brass. Naturally, allowance must be made for the lower melting point as compared with metals, and the relative flexibility in thin sections. Simple shapes can, if desired, be stamped from extruded strip up to about $\frac{1}{16}$ in. thick.



Nylon worm wheel assembly in A.C.-Delco windscreen wiper moulded by Punfield & Barstow Ltd.

TABLE 2. Properties of nylon types

Type and Trade Names	Type 66– Maranyl A100/M Zytel 101	Type 6– Akulon Grilon Durethan	Type 610– Maranyl B100/C Zytel 31	Type 11– Rilsan
Density, gm./cc.	1·14	1·13	1·09	1·04
Melting point, °C.	264	220	220	190
Moisture absorption, % at 65% R.H.	3·0	3·5	1·5	0·7
Young's Modulus, p.s.i.	$4{\cdot}3 \times 10^5$	$4{\cdot}0 \times 10^5$	$3{\cdot}0 \times 10^5$	$2{\cdot}0 \times 10^5$
Tensile strength, p.s.i.	11,500	10,000	8,500	8,500
Elongation at break, %	80–100	150–200	100–150	90–120

Design of Nylon Parts

Although nylon has the advantages described above, it is, of course, different from metals in a number of other important respects and, to the design engineer used to working with the latter, these can cause difficulty unless he is fully aware of their nature. It is the purpose of the remainder of this article to discuss these factors and indicate their relevance to the successful design of nylon components.

VARIATION OF MECHANICAL PROPERTIES—When using nylon as an engineering material particular attention should be given to its property of absorbing moisture from the atmosphere. Thus a dry, freshly moulded article will on storage pick up water slowly until an equilibrium condition is attained. Fig. 1 (see next page) illustrates this effect on an $\frac{1}{4}$-in. moulding exposed to an atmosphere of 65 per cent relative humidity. It will be noted that the water content continues to increase slowly over a period of about one and a half years until an equilibrium water content of 3 per cent is attained. This equilibrium concentration is dependent solely on humidity; it is substantially independent of temperature and thickness of the moulding, though these variables will, of course, influence considerable the *rate* at which moisture is absorbed. The variation of equilibrium moisture content with atmospheric humidity is shown in Fig. 2.

Nylon is not affected chemically by the uptake of water, but it does have a softening action, altering the physical properties of the mouldings. Thus as the moisture content increases so does the tensile strength and stiffness of the material decrease and the impact strength increase. These effects are illustrated in Figs. 3, 4 and 5 respectively. It will be seen that for "normal" atmospheric conditions, i.e., a relative humidity of 60-70 per cent, which gives rise to an equilibrium water content of about 3 per cent, the limiting modulus and yield strength are $2{\cdot}0 \times 10^5$ p.s.i. and 8,000 p.s.i. respectively. These are the values which

should, under such conditions, be taken for design purposes.

Increase of temperature has a similar effect to absorbed water on mechanical properties (see, for example, Fig. 6), though temperature variations arising under normal atmospheric conditions do not have as great an effect as moisture pick-up.

DIMENSIONAL VARIATION—It is not possible to maintain such a high degree of accuracy of dimensions when manufacturing nylon parts by injection moulding as it is when machining or indeed pressure die-casting metal parts. This arises from the practical difficulty of controlling the relatively high shrinkage (of the order of 0·020 in. per in.) which occurs during solidification and cooling in the mould. Much can be achieved by careful control of injection machine variables, but general experience indicates that limits tighter than about ±0·002 in. per. in. are impracticable in most instances. It should be appreciated, however, that many nylon components can accommodate dimensional inaccuracies which would be quite unacceptable with metals.

Control of the dimensions of nylon parts is also complicated by the absorption of water from the atmosphere, since this causes swelling. From Fig. 7, which relates the linear dimensional change with water content, it will be noted that within the range 0-5 per cent water, a change of 1 per cent produces a change in linear dimension of roughly 0·2 per cent (0·002 in. per in.). Thus, supposing a dry nylon gear wheel of 2 in. diameter is put into service in an environment of 65 per cent relative humidity, it will over the course of a year or so, depending on its thickness, absorb 3 per cent of water and increase in diameter by 0·012 in.

Provided that the average humidity which will be experienced in service is known, and is not subject to wide variations, these changes can be reduced to negligible proportions by pre-treating the part in water, or "normalising" as it is often called. This consists quite simply of immersing the moulding in boiling water until it has attained a water content equal to the equilibrium value appertaining to the operating humidity, i.e., about 3 per cent for average conditions.

The required time of immersion varies with thickness, but it is usually only a matter of an hour or two (see Fig. 8). After boiling, the moulding should be stored for about two weeks to allow the moisture to distribute itself throughout the mass, and the dimensions then checked. The moulding cavity dimensions should, of course, be related to the dimensions of the article in this normalised condition rather than in the as-moulded condition. Day-to-day fluctuations in humidity will have little effect, since the rate of diffusion of moisture at atmospheric temperatures is low and dimensional variations greater than ±0·001 in. should not occur in a normalised moulding.

Naturally if the component is to operate under varied atmospheric conditions (e.g., in all parts of the world), this degree of dimensional variation will be exceeded. Thus if it is assumed that average relative humidities ranging from 40 to 90 per cent will be encountered, normalisation to 4 per cent moisture content would still allow of variations

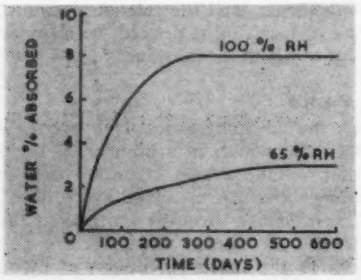


FIG. 1. RATE OF ABSORPTION OF ⅛ IN. THICK MOULDINGS

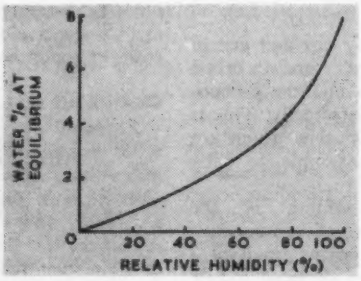


FIG. 2. VARIATION OF EQUILIBRIUM WATER CONTENT WITH RELATIVE HUMIDITY

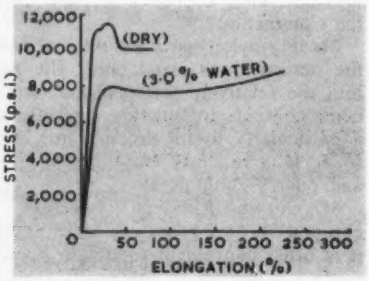


FIG. 3. INFLUENCE OF ABSORBED WATER ON TENSILE PROPERTIES

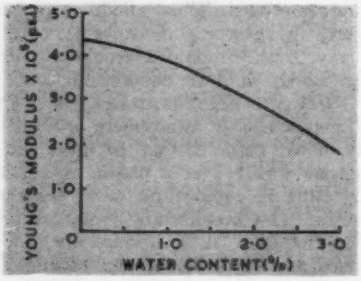


FIG. 4. AFFECT OF ABSORBED WATER ON YOUNG'S MODULUS

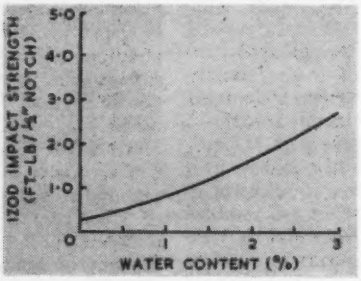


FIG. 5. AFFECT OF ABSORBED WATER ON IMPACT STRENGTH

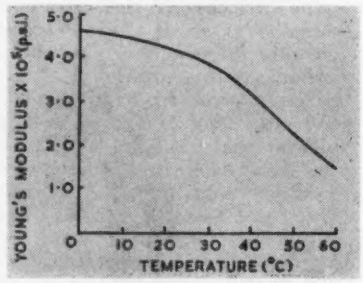


FIG. 6. AFFECT OF TEMPERATURE ON YOUNG'S MODULUS OF DRY MOULDINGS

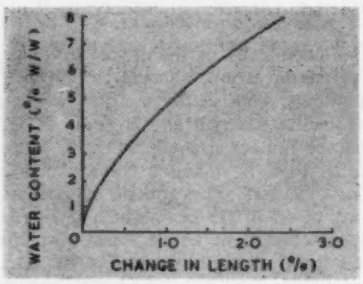


FIG. 7. VARIATION OF LENGTH WITH WATER CONTENT

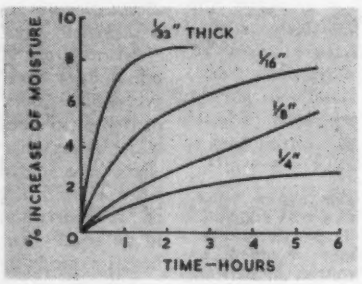


FIG. 8. RATE OF MOISTURE PICK-UP OF MOULDINGS IN BOILING WATER

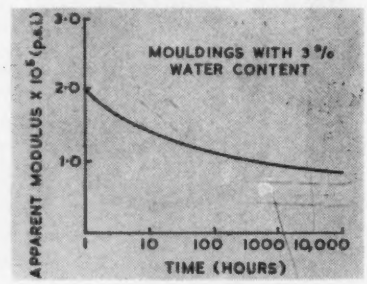
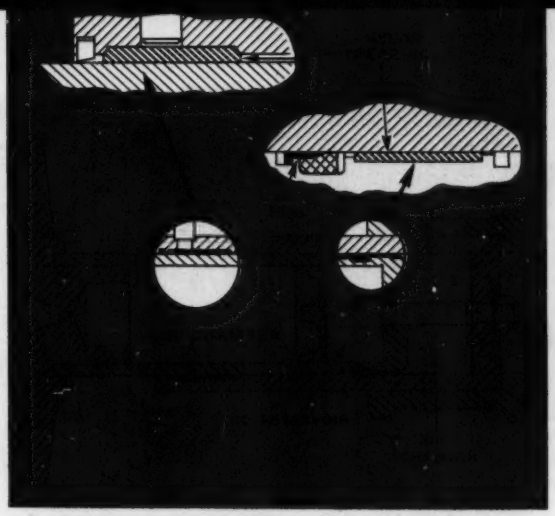
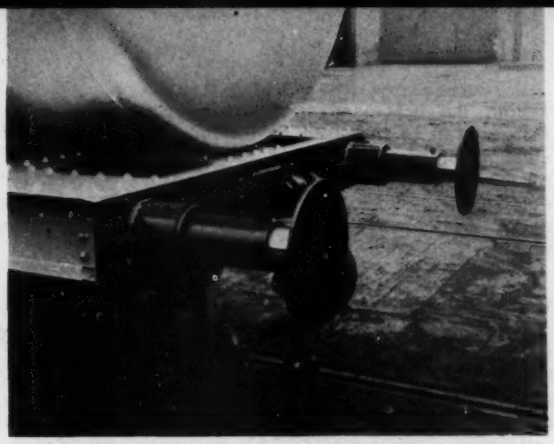


FIG. 9. RELATIONSHIP BETWEEN APPARENT MODULUS AND TIME





Rail tanker (made by Chas. Roberts & Co.) with Oleo-Pneumatic buffer incorporating—see *left*—nylon bearings and seals.

of the order of ±0·004 in. per in. If such variations cannot be accommodated, one of the less hygroscopic, though perhaps more expensive grades of nylon based on type 11 or type 610 should be used.

In carrying out the normalisation treatment recommended above, it may sometimes be found that the increase in dimensions obtained is less than would have been predicted from Fig. 9. This is due to the release of internal stresses set up during moulding, causing shrinkage of the article. Such stresses can often be minimised or avoided by choice of suitable moulding conditions, particularly a high mould temperature. If not, in most instances, the normalisation treatment in boiling water will serve also as an annealing treatment and avoid possible dimensional variations due to slow release of stresses in service.

In relation to the problem of dimensional stability, it should be noted (see Table 1) that the coefficient of linear thermal expansion of nylon is some five to ten times greater than that of metals. Thus a temperature change of 10 deg. C. produces a linear dimensional change of 0·001 in. per in.

COEFFICIENT OF FRICTION AND ABRASION—It is impossible to quote values for coefficient of friction which are generally applicable, since this property is specific to the particular conditions involved. Thus, for example, the applied load, the speed of slip and the condition of the nylon surface (e.g., whether moulded or machined) all have an important influence on the result obtained. Therefore, the data given in Tables 3 and 4, which were obtained under the specific conditions indicated, should be taken as a guide only.

It is similarly difficult to give a quantitative indication of the abrasion resistance of nylon on the basis of laboratory tests. General experience indicates that it is a very hard-wearing plastics material and in many instances will outlast the softer metals and alloys such as brass and phosphor bronze. Abrasion resistance is increased by the use of external or internal lubricants, and detailed variations of this property can also be effected by varying moulding conditions. Thus injection into a hot mould produces a harder and rather more wear-resistant surface than a cold mould. Similarly, surface hardness can often be increased after moulding by annealing at 150-200 deg. C. in a suitable non-oxidising fluid (e.g., mineral oil). Components cut from extruded bar are often harder and slightly more wear resistant than the comparable injection-moulded pieces.

TABLE 3—Kinetic coefficient of friction of type 66 nylon

Moving Surface	Stationary Surface		
	Nylon (moulded)	Nylon (machined surface)	Mild Steel
Nylon (moulded)	0·63	0·52	0·31
Nylon (machined surface)	0·45	0·46	0·33
Mild steel	0·41	0·41	0·6–1·0

The figures quoted in Tables 1 and 2 were determined on an apparatus consisting essentially of a loaded hemispherically-ended slider held in contact with a moving plate. The speed of slip was 1 cm./sec. and the applied load 2 kg.

Change of Apparent Modulus

COLD FLOW—One factor less frequently encountered with metals than with plastics is the phenomenon of cold flow. In other words, if a given stress is applied over a prolonged period, say several weeks, the strain obtained will be greater than that prescribed by the modulus of the material. Thus the apparent modulus is dependent on the period of observation and will decrease with time as illustrated in Fig. 9.[1, 2]

It will be noted, however, that most of the change in apparent modulus takes place within the first few days of observation. Thus, if in a particular application it is not possible to estimate the extent of cold flow, a useful practical indication can be obtained from trials extending over a few days. Assemblies incorporating nylon washers or gaskets should, generally speaking, be re-tightened a week or so after assembly. Cold flow is not often a serious practical problem, but should always be considered in such applications as sliding door rollers where the part can remain loaded in the static position.

AGEING—Nylon, although it has a much higher softening temperature than most thermoplastics, will not withstand continuous exposure to elevated temperatures, if air is present. Thus if nylon components are operated continuously at temperatures higher than about 60 deg. C., surface discoloration will occur and the impact strength of the moulding will be reduced. The rate of embrittlement will, of course, depend on the actual temperature, but at 100 deg. C. the useful life of a moulding will be of the order of four to six weeks. A considerably longer life can be anticipated if the moulding is shielded from direct contact with air, e.g., if it is immersed in oil. At normal atmospheric temperatures, nylon will retain its properties indefinitely, provided it is not exposed to direct sunlight which also induces degradation. For this reason the useful outdoor life of the material is limited and may be only one to two years in extreme cases, such as under tropical conditions.

Both the heat- and light-resisting properties of the material can be improved by the incorporation of small amounts of certain chemical additives, and a grade of nylon modified in this way should always be used for outdoor applications. However, at the present time most nylon components are used under conditions where the problem of weathering does not arise.

Gears and Bearings

Nylon gears operate satisfactorily either in all-nylon systems or in conjunction with metals, with the possible exception of brass. Nylon abrades brass. Within the range of conditions limited by the strength of the material, gears can normally be operated without lubrication, though in extreme cases the danger of localised overheating and melting may necessitate lubrication by water or oil.

In designing nylon gears, formulæ of the same form as those used for estimating the strength of metal gears can be used to give a guide to performance. For example, according to B.S. 436:1940, the horsepower rating of helical and spur gears is given by the formula:

$$\text{H.P.} = \frac{X_b S_b Y F N T}{126{,}000\ P^2}$$

where X_b = speed factor for strength; S_b = bending stress factor; Y = strength factor; F = face width (in.); N = speed of revolution (revs./min.); T = number of teeth; and P = diametral pitch.

The speed factor X_b for non-metallic gears is normally taken as

$$X_b = \frac{150}{200 + V} + 0.25$$

when V = pitch-line velocity in feet per minute.

S_b, the bending stress factor, reflects the stress-bearing capabilities of the material under static conditions, i.e., the tensile stress at yield in the case of nylon. Thus, under normal working conditions, i.e., 60-70 per cent. relative humidity, a figure of 8,000 p.s.i. will be applicable, reduced by a suitable safety factor. Three is a suitable safety factor for most purposes.

The strength factor is dependent on the tooth form, and the number of teeth in contact and, as a first approximation, the figures applicable to metallic gears may be used. In actual fact the latter will give a conservative indication in the case of nylon, since its greater resilience enables loads to be spread over a wider surface area.

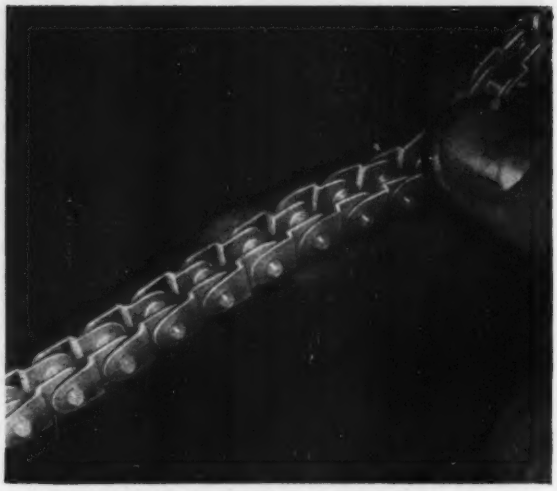
The change in tooth profile resulting from shrinkage during the injection-moulding process is sufficiently small to be disregarded in almost all cases. Naturally the pitch diameter of the mould must be made sufficiently large to allow for radial shrinkage of the gear.

TABLE 4—Effect of lubricants on kinetic coefficient of friction of type 66 nylon (like surfaces)

Lubricant	Coefficient of Friction
None	0·46
Water	0·24
Liquid Paraffin	0·13
Graphite	0·28

TABLE 5—Maximum p.v. values for type 66 nylon bearings

Lubricant	Type of Operation	
	Continuous	Intermittent
None	500–1,000	3,000
Water	1,000–1,500	4,000
Oil Initially	2,000	8,000



Nylon chain moulded by G. Goodman Ltd.

BEARINGS—As with nylon gears, abrasive wear is not often a relevant consideration in the design of nylon bearings. The upper limit to operating conditions is normally set by the surface build-up of frictional heat, arising from the poor thermal conductivity of the material. Thus the coefficient of friction under the operating conditions will be an important factor and, as has been indicated earlier, this is dependent on many variables. American workers have attempted to give some guidance on the maximum p.v. values (the product of load in p.s.i. of projected bearing area and the peripheral speed in feet per minute) which can be tolerated by nylon bearings, and typical values[2] are reproduced in Table 5.

It should be emphasised once again that these values are indicative only, and practical trials should always be carried out to determine the limit applicable under the specific conditions of surface, wall thickness and clearance being used. It is difficult to give even an approximate guide on maximum p.v. values when the bearing is lubricated continuously but they are undoubtedly very much higher than those indicated in Table 5.

Nylon bearings should, of course, be normalised to the approximate moisture content before fitting into their metal housings. Ideally, there should be negligible interference and the nylon sleeve held in position by a metal key or similar mechanical device. If a press fit is used, the internal diameter should be measured subsequently, since rather large interferences are required to obtain a good fit, and essentially all the interference results in a proportional decrease in internal diameter. Dimensional checks should be carried out several days after assembly to cater for any cold flow resulting from the internal stresses set up. For bearings 1-2 in. internal diameter of wall thickness 0·1-0·2 in., interferences of the order of 0·005-0·010 in. will normally be suitable.

It is usually advisable to allow greater clearance on the shaft than with metal bearings, particularly if it is not possible to ensure a constant moisture content by normalisation. Indeed, small clearances are not essential with nylon to ensure smooth running and a satisfactory life. A clearance of 0·005 in. per in. may be taken as a guide for bearings operated with little or no lubricant.

REFERENCES
(1) Proceedings of A.S.T.M. (1954), **54**, 1313-29.
(2) *Plastics Technology*, April 1956, 221.

NEW IDEAS IN DESIGN

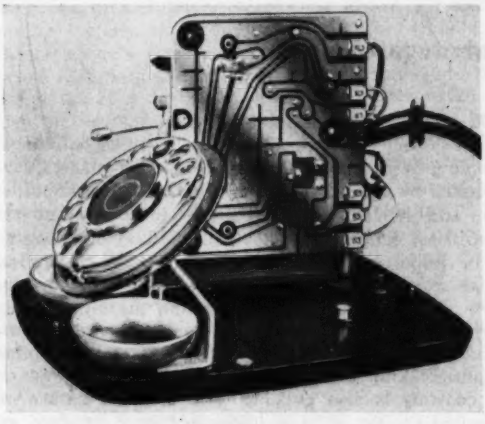
Outstanding products in current manufacture

Telephone Handset Uses New Materials

BY employing a number of new materials and manufacturing techniques, together with improved electrical and mechanical features, Siemens Edison Swan Ltd. have produced in the Centenary Neophone a new telephone handset which is both durable and elegant and suitable for use even in tropical conditions.

Injection mouldings in high-impact polystyrene, without metal inserts, have greatly lightened the instrument, the handpiece being now more than 50 per cent lighter than its compression-moulded predecessor. Complete restyling has also eliminated the cup-type of mouthpiece.

Removal of the moulded case reveals the mechanical and electrical details. Apart from the two gongs and the dial mechanism, these are attached to a synthetic resin panel, the underside of which provides the wiring of the instrument in printed circuit form. Wires from the



electrical components pass through the panel and are soldered to it, tags from the handset and line cords, which are of nylon-braided p.v.c., being clamped by quick-thread screws to clips soldered into position on the rear edge of the panel.

The gravity switch, of simplified design, is operated by a pivoting platform which is caused to tilt by two p.t.f.e.-tipped plungers in the case. Rubber seals prevent the entry of dirt and insects, the gong vents being sealed by a thin p.v.c. disc which also serves for sound transmission. Moulded bobbins, which accept the windings directly and separate carbon resistors of the ceramic insulated type, for spark quenching, which can be easily replaced, are further examples of the many good design features for production embodied in this instrument.

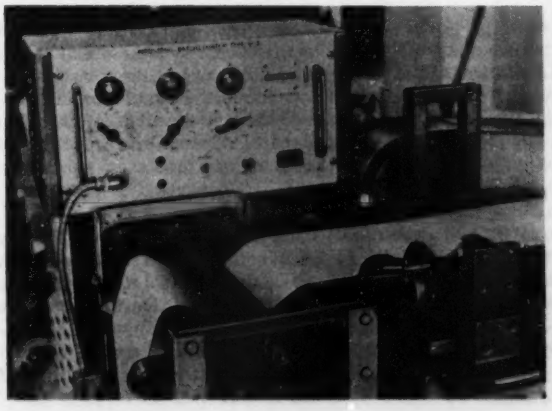
Electronic Batch Counter Assists Lampshade Production

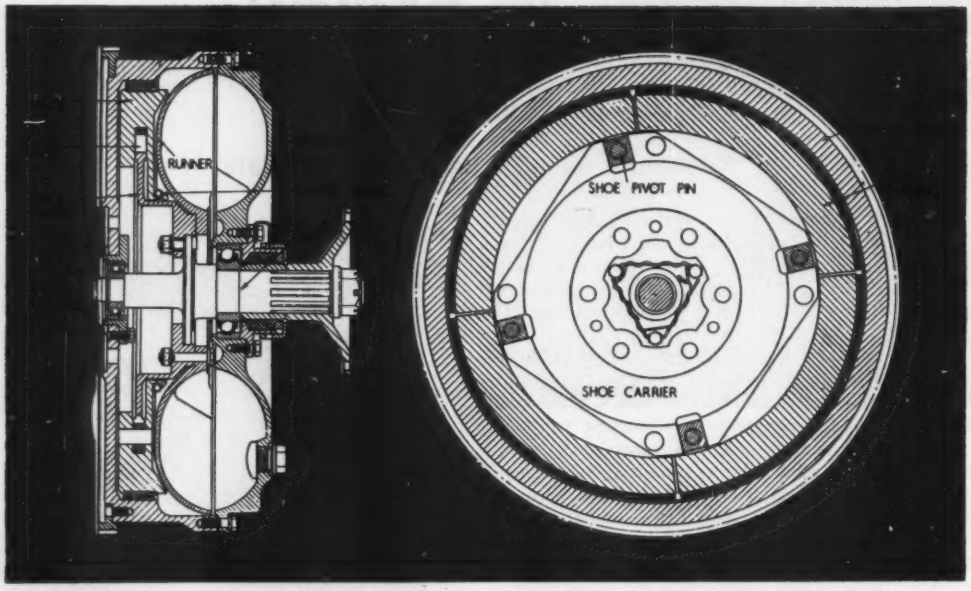
AN example of how an electronic batch counter can be used to solve a problem in the design of special-purpose machinery for production is provided by a machine developed by Waite & Son Ltd. in conjunction with the Electronic Machine Co. Ltd. The problem involves accurate notching of lampshade material prior to cutting. Shown in the illustration (*right*) is the B.C.3 batch counter which was installed at a Mitcham lampshade factory.

To provide precise measurement of the lampshade material, a series of holes is drilled in a metal disc mounted on the same axis as the roller over which the material passes. The hole spacings are arranged to correspond to 1-in. of material travel over the rollers. Successive increments of movement are signalled to the batch counter by a photocell and light head, the light from which passes through the holes in the disc.

As the batch counter can be set to operate a relay at any desired count, which operates the notching wheel, the material cutter can be speedily changed to cut material to any desired length without the disadvantages of special tooling set-ups.

The cutting of material to length, whether in sheet, rod or wire, batch weighing and the operation of production machinery by remote control are all problems for which electronic counters can provide a solution.





Combined Fluid and Centrifugal Coupling

IN combining the fluid and centrifugal types of coupling in one unit, Self-Changing Gears Ltd. have produced a means whereby smooth take-up from rest is ensured, together with positive grip of the friction members at high speeds.

By reducing the cross-sectional area of the fluid coupling, it has been possible to leave a space between the runner and the inside face of the flywheel. Inside this space the centrifugal coupling components are compactly arranged. The shoe carrier disc, the flange of which is square, is bolted to a flange on the output shaft. To the four corners of the disc are attached the four brake shoes by the shoe pivot pins. It will be seen that an additional set of holes is provided to enable the shoes to be mounted with leading or trailing characteristics. A garter spring holds the shoes in the retracted position.

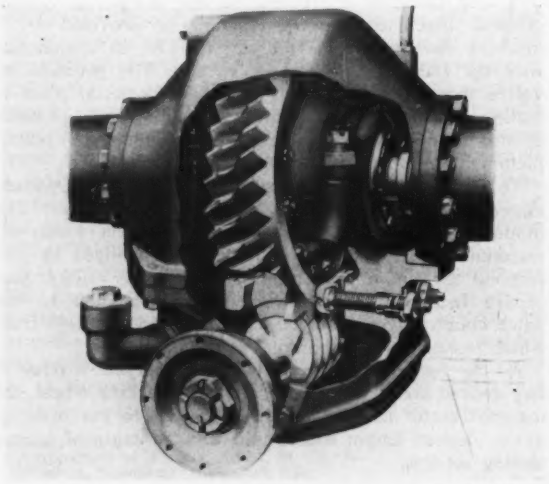
The lower torque-transmitting capacity of the fluid coupling at high speed, due to reduction in area, is compensated by the centrifugal member. As output shaft speed rises and the friction clutch shoes are thrown outward by centrifugal action, efficiency in the fluid coupling ceases to be important as the drive is taken up by the centrifugal components.

As the clutch shoes are carried on the output member, they can be fully engaged by the centrifugal effect of road speed driving through the transmission, thus retaining engine braking down to idling speed. Starting an engine by coasting is also possible. The compact nature of the coupling enables it to be embodied in a standard engine layout without much difficulty.

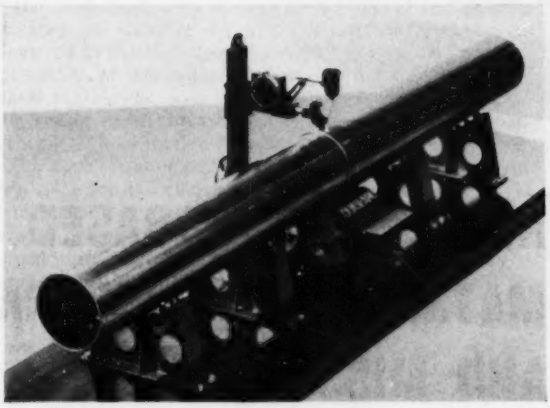
Thrust Pads Prevent Worm Wheel Distortion

THE provision of two thrust pads ensures correct meshing of worm and wheel in differential gears now being fitted by Leyland Motors Ltd. to their Worldmaster passenger vehicle; a sectional view of this differential is shown *right*. It has been found that, even when stiffer bearings are used, twisting of the worm wheel under full torque inevitably occurs. This results in tooth displacement and wear.

The wear pads, each about 5 in. long and 1¼ in. deep, are held in position on each side of the worm wheel by large adjusting screws fitted with squared ends and lock nuts. These enable any wear of the blocks to be taken up without dismantling the assembly. The clearance between each pad and the worm wheel is ·002 in. This simple modification is claimed by the manufacturers to have revolutionised the life expectancy of their worm and worm wheel drives.



Pipe-welding Machine Halves Manual Welding Time



A NEW machine for speeding up pipeline welding on site, a model of which is illustrated, has recently been announced by Quasi-Arc Ltd. Lengths of pipe 30-40 ft. long can be welded together automatically, the double length then being joined to the pipeline by conventional manual welding methods.

Two idler units, carrying six ball castors arranged in a V-formation, support each length of pipe to be welded. Rotation of the pipes is effected by two pairs of large-diameter rubber-covered rolls, each driven by a ½-h.p. motor supplied from a motor-driven generator with Ward-Leonard control. Reduction gearing enables welding speed to be varied from 7 in. to 70 in./min. When welding is completed, the driving rollers can be disengaged from contact with the pipe by a handwheel which operates a left- and right-hand screw. It is then possible to move the completed pipe over the ball castors lengthwise.

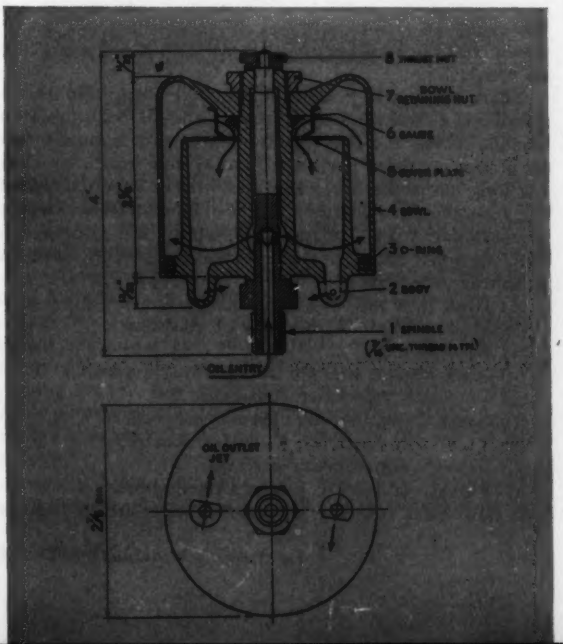
Several makes of welding head can be used.

Optical Protractor Simplifies Spindle Setting

THE accurate positioning of angular milling cutter spindles is normally carried out by approximate setting of the milling head to the desired angle, followed by trial cutting. An optical dial protractor by Miller of Innsbrück simplifies setting or re-positioning of the spindle and makes trial cuts unnecessary. Much greater accuracy is possible than with conventional methods, settings to three-thousandths of a degree being claimed by the makers.

By the use of interchangeable taper shanks, the instrument can be fitted in all types of machine-tool spindle. For approximate setting, the ordinary graduations are read with the naked eye, subsequent fine setting to 10 seconds of arc being achieved by the examination of high-precision graduations on glass with the aid of a built-in microscope giving 50× magnification. To ensure that the graduated dial of the instrument and the swivel plane of the spindle are parallel, a telescopic sight fitted with a graticule is combined with the microscope. This enables the table to be viewed and any adjustment made to bring the swivel plane of the spindle at right angles, in plan view, to the direction of table movement.

A built-in adjustable level enables corrections to be made for deviations from the zero position on the spindle.



New Filter Uses Turbine Principle

A CENTRIFUGAL by-pass filter designed to form an integral part of the engine lubrication system of motor-cars and diesel engines is announced by Glacier Metal Co Ltd. It can be built into the engine oil-filter assembly, crankcase or other suitable part of the engine, and can be used either individually or in conjunction with a normal pack-type filter. Operating on the turbine principle, the filter has been designed for engine oil pressures of from 15-80 p.s.i. and can accommodate an oil circulation of between 10-40 gallons of oil per hour.

The filter bowl, which is secured to the rotor unit, revolves about a steel spindle at speeds of up to 9,000 rev./min. Oil enters through the central spindle and dirt is separated and collected on the inside of the filter bowl; returning oil passes out through the jets in the base of the unit, which give rise to the high rotational speed.

Fig. 1. Firestreak missile with resinated asbestos felt fins on the DH Sea Vixen.

NEW ASBESTOS-BASED MATERIALS FOR AIRCRAFT AND MISSILES

by C. Z. CARROLL-PORCZYNSKI*

The answer to many recent problems involved in construction for high-speed flight—principally those of heat, high strength, low weight and corrosion resistance—has been found in the use of asbestos-based materials

IN the field of fibrous materials, asbestos occupies a unique place. It is the only known natural mineral fibre and, in addition, it combines the following properties to make a most versatile industrial fibre.

(i) It is resistant to weather, corrosion, fire, heat, acids and alkalis.
(ii) As an insulator it is effective against vibration, electricity, sound and heat.
(iii) By virtue of the fibre strength and flexibility, it serves as a reinforcing and binding element for magnesia, cement, resins and rubbers.
(iv) It serves as an efficient filtration medium for acids, alkalis, sludge and dust.

The term "asbestos" is applied rather loosely to a large group of fibrous minerals, the most commonly distributed type and one that possesses the best spinning properties being chrysotile asbestos. This has a tensile strength of 300,000 to 400,000 p.s.i., an E value of $26{\cdot}5 \times 10^6$ p.s.i., and a fusion point of 1,521 deg. C.

Other varieties of smaller importance are blue or crocidolite asbestos and amosite asbestos, both having superior resistance to acids than the chrysotile type, but being inferior in some physical properties, such as flexibility and abrasion resistance.

Rockets and Missiles

One of the great problems facing constructors of rockets and missiles has inevitably been the finding of suitable materials capable of resisting intense heat generated by internal combustion of up to 3,570 deg. C., with accompanying erosion by hot gaseous products and by external frictional forces producing even higher skin temperatures upon re-entry of the missiles into the earth's atmosphere.

Parallel with rocket and missile developments, there is, of course, enormous progress in the field of reinforced plastics. These materials have already proved to be more suitable in guided missiles and rocket applications than conventional metals, though it should be understood that no known material exists which could withstand continuously the high temperatures involved. Nevertheless, some of the recent reinforced plastics are sufficiently heat resistant to withstand such temperatures for the duration of the service without causing structural failure.

From the data so far available, it appears that phenolic resin reinforced with asbestos fibres is at present one of the most suitable materials. As a comparison with the behaviour of metals, it has been recently reported that it will take 180 sec. to burn through 0·85-in.-thick asbestos-phenolic material at a temperature of 2,480 deg. C., with a gas velocity of Mach 0·5, while under the same conditions, a 1-in.-thick steel material has a burn-through time of only 80 sec. In general, erosion rates for certain asbestos-phenolic proprietary materials are stated to be in the region of 0·0052 to 0·0072 in./sec. on flat panels exposed to a temperature of 2,595 deg. C. and gas velocities of Mach 2·5.

Titan, Vanguard, Polaris, Sidewinder, Tartar and Terrier missiles use laminated or moulded asbestos heat-insulation shields, tubing and heat diverters. The raw materials used in producing these parts are Pyrotex felts made by carding long chrysotile fibres and also various asbestos moulding compounds. According to the manufacturers, Raybestos-Manhattan Inc., these felts, which are impregnated with phenolic, epoxy, silicone or polyester resins, have the following properties:

(a) High heat and flame resistance.
(b) High stiffness or modulus of elasticity.
(c) High strength.
(d) High impact strength and porosity resistance.
(e) Chemical and water resistance.
(f) Good insulation and thermal properties.
(g) Very high resistance to surface crazing.
(h) Smooth non-abrasive surfaces.
(i) Readily layered to produce thick sheets.

The nose cone (see Fig. 3) which protects the Vanguard

* *Manager, asbestos division of Metal Traders Ltd.*

satellite is approximately 6½ ft. long and 30 in. in diameter at the base. It is made of Pyrotex felt and phenolic resin, and is tipped with a point of solid titanium. The function of the nose cone is to streamline the rocket and insulate the enclosed satellite from friction-generated heat encountered in the high-speed upward flight which will reach an altitude of 300 miles or more and a speed of around 18,000 m.p.h. The nose cone is also protecting the 72-ft.-long rocket from ram effect caused by aerodynamic loading while it is in motion through the air.

The cone is moulded in two parts, so it can divide and drop off when the rocket is above the densest part of the atmosphere. The material was selected for this leading role because of its low weight and ability to retain strength at temperatures above 540 deg. C. It weighs 0·065 lb./in.^{3} compared with 0·10 for aluminium, 0·17 for titanium, 0·28 for steel and 0·32 for nickel. This is a highly significant factor in a rocket where every ounce is important.

Asbestos-phenolic moulding compound has been successfully used in the fabrication of sliver traps for rockets. The purpose of the trap is to retain propellent slivers within the rocket during the burning of propellents. Without the trap, long-burning slivers will be emitted through the nozzle and possibly cause fires in the surrounding area if burnable material is present.

A turbine wheel operating in a missile is rotated by burning gas which propels the buckets located at its circumference. The wheel, thus motivated, drives an electrical

Fig. 2. 100-gal. drop-tanks made from asbestos-reinforced phenolic by Bristol Aircraft Ltd.

generator. In fabricating the turbine wheel, asbestos-phenolic moulding compound was used because it can meet the physical requirements (100,000 r.p.m. spin test) and temperature requirements (1,095 deg. C. for 45 sec.).

Pre-impregnated Pyrotex felts are also used as an inside lining for metal and plastic rocket tubes. In this case, pre-impregnation provides suitable adhesion, heat resistance, thermal insulation and simplicity in applying a liner as compared with the standard technique which involves brushing or spraying paint-type coatings. Recently it has been reported that a 5-in. diameter rocket called "LAR" uses asbestos-phenolic tubing as lining for the combustion chamber.

Recently, Continental-Diamond Fibre Corp. announced a new group of asbestos-base phenolic materials in the

Photo: Martin Co.

Fig. 3. Vanguard nose cone in Pyrotex felt.

form of laminates called Dilecto and moulded products called Celoron. It is claimed that these laminates and moulded parts have withstood temperatures of 1,370 deg. C. and 1,930 deg. C. for limited periods, and that they are suitable for applications based on the new concept of "ablation" or "using up" of materials in certain rocket and missile operations, where temperatures of 2,205-2,760 deg. C. are encountered.

In the U.K. a wide range of asbestos resinated felts, moulding flock and powders has been developed by Turners Bros. Asbestos Co. These materials are marketed under the trade-name Durestos. Table 1 shows the performance of type RA.1, which is a high-strength grade felt incorporating long chrysotile asbestos and phenolic resin.

This type of resinated-asbestos felt is used, among other

Photo: Martin Co.

Fig. 4. Removing from the mould half of the Vanguard nose cone.

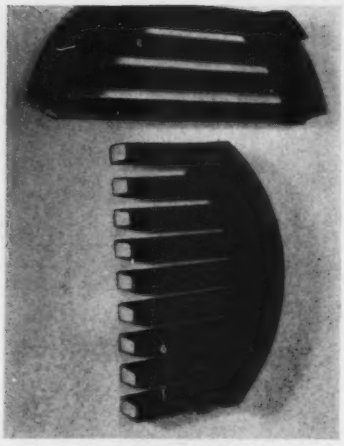


Fig. 5. Rocket sliver trap of asbestos-phenolic moulding compound by Raybestos-Manhattan Inc.

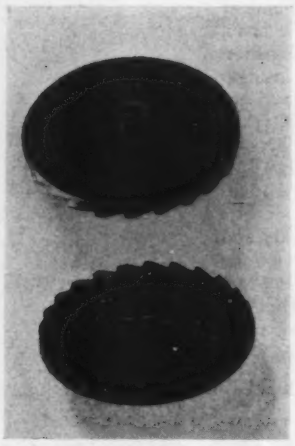


Fig. 6. Turbine wheel of asbestos phenolic moulding compound for rocket generator.

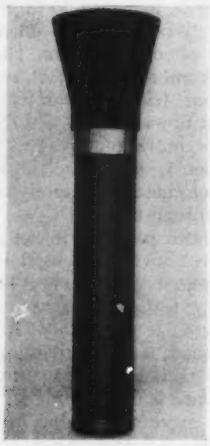


Fig. 7. Bristol rocket tube in phenolic resin-impregnated asbestos.

Fig. 8. Laminated-asbestos-based nose-wheel bearing for the Vickers Viscount by Coin Insulation Ltd.

purposes, for the manufacture of wings and fairings of the Firestreak air-to-air missile which is in full production at the factories of de Havilland Propellers Ltd.

Another example of its application in this field is the Bristol-Ferranti Bloodhound twin-ramjet anti-aircraft missile. In this case, expansion cones for nozzles of boost motors are made of resinated-asbestos felt. Bristol Aircraft Ltd. are also producing a range of other asbestos-based missile components, such as nozzles for motor tubes, missile tail pipes and heat barriers. Several asbestos-based missile parts are also being produced in the U.K. by Coin Insulation Ltd.

Bristol Aircraft Ltd. have patented (B.P. 778,682) a process for the manufacture of fuselages for guided missiles. According to this invention, such a fuselage consists of a moulded tubular skin with integral longitudinal stiffeners and with at least two diaphragms made from a heat-hardenable resin adhesively secured to the skin. The skin is made from felts about 0·085 in. thick and consists of equal parts by weight of asbestos fibre and phenol formaldehyde resin. The moulding of this fuselage is carried out at a pressure of about 100 p.s.i., and a temperature of 140 deg. C.

While reviewing recent developments in the missiles field, mention should be made of a novel material developed by Taylor Fibre Co. of Norristown, Penn. It is a laminate of an asbestos mat base impregnated with a special phenolic resin and of nylon fabric impregnated with the same material. It is claimed that the composite plastic, called Grade HT-5000, has withstood a five-minute test at 1,095 deg. C. Also a new phenolic resin called Plyophen 5900, developed by Reichhold Chemicals Inc., is likely to enter the missile field. It has been stated that this resin, reinforced with asbestos, will withstand 2,480 deg C. for brief periods or 260 deg. C. for 100 hours.

Aircraft Industry

For aircraft and other structures, where a high strength/weight ratio and resistance to corrosion and fatigue are of primary importance, plastic materials have great and well-known advantages. In recent years, the Bristol Aircraft Ltd. have undertaken investigations to assess the suitability of laminates for complete wing and fuselage structures. It was estimated from tests that, on a strength/weight basis, the moulded wing was some ten per cent more efficient than an equivalent structure in aluminium alloy and its production costs were considerably lower.

Fuel drop-tanks, however, are today perhaps the best example of a successful application of asbestos-reinforced plastics in the aircraft industry. Normally used on fighters for extra fuel, they have also been fitted to larger aircraft, such as the Canberra jet bomber, and they have been used as containers for water in the control of bush fires. A plastics gel bomb has also been developed from the Bristol asbestos-phenolic fuel drop-tank. It is essentially a standard plastics drop-tank fitted with an igniter in place of the filler cap. It is claimed that the plastics gel bomb is superior to the metal type, because fragmentation is more complete and the distribution of the contents over the target area is wider and more even.

Among other processes, Bristol Aircraft Ltd. have developed a method of moulding various structures from fluid mixtures of fibrous asbestos and bonding material, which permits the alignment of fibres in accordance with the desired pattern. It is claimed that a turbine blade produced by this method with asbestos fibres aligned along the length of the blade has 50 per cent higher tensile strength than that made from an unoriented material.

A process for making aerofoil skin by vacuum moulding has been patented by National Research Development Corp., wherein the use is made of several layers of asbestos felt impregnated with aqueous solution of phenol-formaldehyde resin, which, just before laying in the mould, are further impregnated with an acetone solution of a stable resorcinol-formaldehyde resin.

One recent example of structural use in modern high-speed aircraft is the cabin floor of the Britannia airliner. Here, the requirements of lightness and strength were fulfilled by the use of two skins of phenolic-asbestos separated and stiffened with bonded end-grain balsa-wood interlayers. It is claimed that this form of construction provides a very rigid component which has good heat- and sound-insulation properties. The cabin air-conditioning system in this aircraft is also trunked in phenolic-asbestos mouldings, some of which are of considerable diameter and complexity of form.

The modern de Havilland Comet employs asbestos-based plastics for the fan housing. Rotor and compressor blades in jet engines, retaining rings, washers, control cable pulleys and sleeves are representative of heat- and wear-resistant phenolic-asbestos parts finding application in the aircraft industry. Bearings machined from asbestos-based laminates are of particular interest to the aircraft engineer, since they are resistant to corrosion and are likely to last at least six times longer than those made from

metal. Fig. 8 shows a spherical bearing made of asbestos-based laminates for the nose wheel unit of the Vickers Viscount series.

Numerous aircraft sealing components also incorporate resinated Durestos felt, a typical example being the jet exhaust sealing ring on the de Havilland Comet. Another example is a compressible fire-resistant seal used for engine hatches and aircraft bulkheads. It consists of a loop-shaped asbestos fabric jacket treated with a fire-resistant adhesive and filled with a stainless-steel wool. It is claimed that this seal has excellent high-temperature properties and, because of its porous construction, will not wick oils or fuels. A further advantage lies in the fact that it returns to its original shape after compression. Asbestos knitted monel wire gaskets developed recently by Metal Textile Corp. are of a similar nature. The most common type, however, is a copper-sheeted asbestos-filled gasket which is being used successfully at temperatures as high as 760 deg. C.

One of the great hazards in aircraft operations is fire, and the most vulnerable equipment are the hose assemblies carrying highly volatile fuels or lubricating oils. According to the U.S. Civil Aeronautics Board, hoses are fireproof if they will stand up to a flame for 15 min. under an internal fluid temperature of 95 deg. C. at a pressure of 35 p.s.i. A hose recently developed by Resistoflex Corp. and incorporating asbestos met this specification with an internal pressure of 1,000 p.s.i. The hose consists of p.t.f.e. tube and a flexible asbestos tubular cover coated with a silicone rubber. Flexible coupling hoses and ductings made of silicone rubber-coated asbestos cloth are also in commercial production in the U.K.

Electrical components incorporating asbestos fibres are also numerous, among them being Ducrasil aircraft cables made by W. T. Henley's Telegraph Works Co. These are silicone rubber insulated, asbestos-roved, glass-braided and silicone-varnished. Another type of cable made by this company is an asbestos-braided copper wire cable.

Monabest, a patented process for insulating electrical leads, makes use of a special machine for applying an adhesive asbestos flock on to a conductor. It is claimed by the firm, Monette Asbestdraht of Marburg, that the coating can be applied in very fine layers, and among other applications, the electrical leads are being used as pick-up leads in aircraft jet engines.

With the steadily growing tendency in both civil and military aircraft for higher speeds comes the demand for more and more heat-resistant structural and insulating materials. Recently, Johns-Manville Corp. announced the development of a new type of moulded low-thermal conductivity material, called Min-K, specially designed for use in high-speed aircraft and missiles, and capable of withstanding temperatures up to 815 deg. C. The manufacturers claim that this insulation could increase the fuel capacity of a rocket or missile by as much as 20 per cent, because its low thermal conductivity permits the employment of a thinner layer than would be required with conventional fibrous insulation.

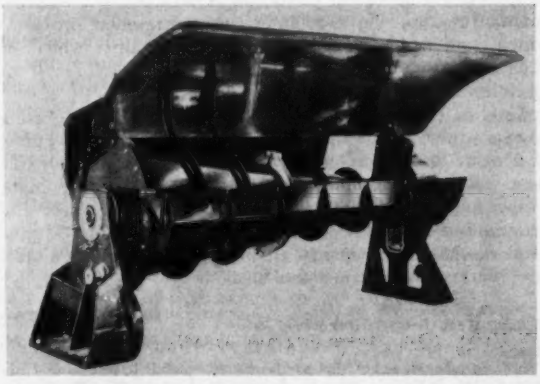


Fig. 9. Radar scanner in Durestos by Bristol Aircraft Ltd.

TABLE I. Physical properties of cured Durestos felt (grade RA.1)

Specific gravity	1·75
Tensile strength—In direction of fibres	29,000 p.s.i.
Compressive strength—transverse ...	19,000 p.s.i.
Compressive strength—edgewise ...	23,000 p.s.i.
—normal to sheet	78,000 p.s.i.
Shear strength—normal to sheet ...	19,000 p.s.i.
Resistance to compression maximum yield —normal to sheet	2·5%
Moulding pressure	560 p.s.i.

Another interesting new asbestos-based material, known as Camco 400, is used for the insulation of ducts carrying high-temperature air on jet aircraft. It consists of Dow Corning C-271 silicone cement and acid-washed asbestos fibres. This insulation may be applied by brushing, spraying, or with a spatula-type tool. A further heat-resistant, asbestos-based, fire-resistant coating has recently been developed by B. F. Goodrich Co. It is claimed that, after heating the coated metal structure for five minutes at 1,040 deg. C, the coating was only moderately discoloured and could not be separated from metal by impact.

Brake linings of asbestos are perhaps the oldest form in which this material is associated with the aircraft industry. Higher landing speeds and increasing weights of modern planes, however, neoessitated the development of more efficient friction materials. Although a great deal of research is concentrated at present on a ceramic type of brake lining, the traditional asbestos type is still in common use. Closely connected with higher aircraft speeds is the development of radar, and, here again, asbestos is being utilised to an appreciable extent. A typical example is a large radar reflector moulded in Durestos felt by F. G. Miles Ltd, to the specification of A. C. Cossor Ltd. Fig. 9 shows a high-speed radar scanner unit developed under a Ministry of Supply contract and manufactured by Bristol Aircraft Ltd.

The moulded components are manufactured from materials comprising asbestos fibres and phenolic resin in the form of flock or felts. These materials produce mouldings which are dimensionally stable under varying climatic conditions, and have high corrosion resistance.

The dielectric properties present a further attractive feature, particularly where high-powered apparatus is required to function successfully in all weathers. In areas continually exposed to sea water and a salt-laden atmosphere, the plastics scanner will function over sustained periods without maintenance, as the anti-corrosion properties are an integral feature of the basic material.

With the steadily growing use of air transport, every effort is made to improve fire rescue equipment. A fire rescue tender which can operate in great heat and cut a rescue hole in the fuselage of a burning aeroplane has been tested recently at airports in Australia. Fitted with three foam generators, it has asbestos blankets which can be dropped like blinds to form a shield between the rescue hole and the heart of the fire. Aluminised asbestos protective clothing and asbestos fire-smothering blankets form a standard part of fire-fighting equipment is practically every modern airport.

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WOOD FOR PIPES AND CYLINDERS

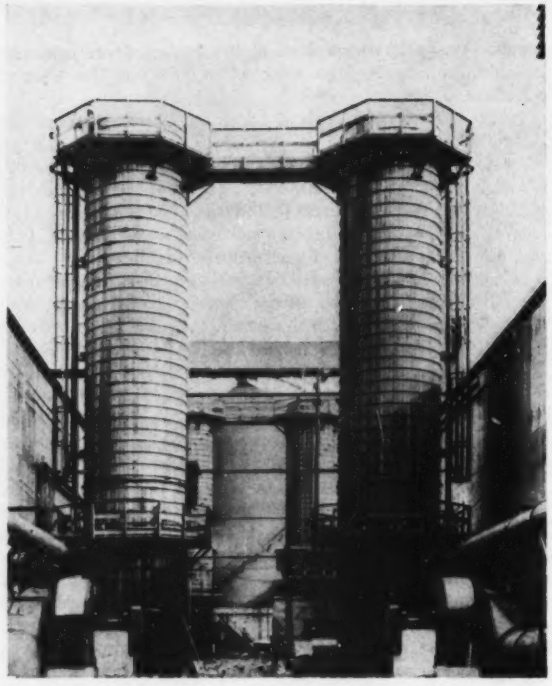
WOOD is one of the oldest materials available for structural and engineering uses, yet it can still hold the advantage over more modern materials for certain applications.

For many years past, the Santa Fe Tank & Tower Co., of California, have been producing wooden scrubbers and pipes; recently these have been made available in the U.K. by their British associate, Head Wrightson & Co. Ltd.

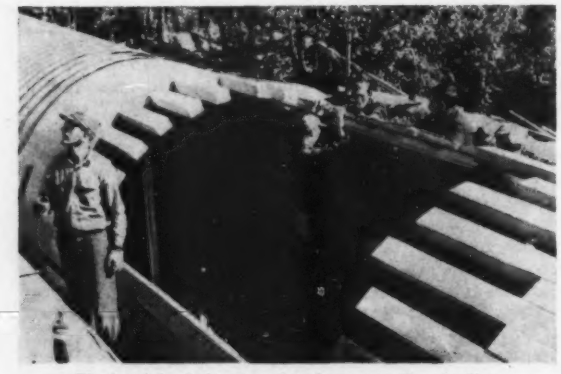
Wood pipe has been shown to have withstood years of service successfully. Being practically a non-conductor of heat, it will not freeze at low temperatures and flexibility prevents bursting and permits curvatures in installation that avoid the necessity for special fittings. As it neither expands nor contracts with heat or cold, it does not require expensive expansion joints. Furthermore, flowing water in wood pipes remains cool, even in those laid on the surface in warm climates, and these pipes can be laid on the surface or buried, as required.

In rough country the cost of wood pipe construction for municipal water systems is said to be frequently less than the provision of open canals; in addition, the water can be conveyed under pressure and the flow is not interrupted by the formation of ice. The pipe is free also from the troublesome growths often found in open canals.

Wood pipe has an almost limitless variety of applications in mines, manufacturing plants, irrigation systems, reclamation projects, hydro-electric plants and many other industrial operations. While economy is one of its primary considerations, it is by no means the only advantage wood pipe can offer. It has, for instance, a greater flow capacity than metal pipe, and this does not decrease with age. It is not affected by electrolysis.



A group of redwood cylindrical wet gas washers.



The last joins being completed on a wooden pipeline.

Cylindrical scrubbers of wood are widely used where the problem of solid or liquid impurities in gas must be eliminated. They are self-bracing and thereby obviate the cost of posts and supporting framework, they require fewer bolts and fastenings, and a minimum of metal parts are exposed to corrosive gases.

These adaptable scrubbers are of wood stave construction. Outside fittings are minimised, and can be furnished in hot-lead dipped steel, monel, stainless steel, brass and bronze. The spray systems are available in various materials. Where the process requires internal air straighteners or drift eliminators, both can be of non-corrosive wood construction.

BEARINGS FOR HIGH SPEEDS AND HIGH TEMPERATURES

THE appearance of air-turbine-driven dental hand-pieces—claimed to operate at speeds from 250,000-300,000 r.p.m.—provide an interesting example of a recent successful high-speed bearing application.

Provided with air at from 10-30 p.s.i. which has passed through a moisture extractor, the air entrains olive oil in mist form which lubricates the stainless-steel ball bearings.

Experiments on more severe applications for high-speed bearings, however, have been the subject of an A.S.M.E. paper by Stanley Gray, of the Stratos division of the Fairchild Engine & Airplane Corp.* Speeds of up to 140,000 r.p.m. were used with temperatures up to 540 deg. C. With 12-mm. bore bearings running at 110,000 r.p.m., no actual failure of the bearings occurred, but it appeared that high temperatures tend to evaporate and coke the lubricant, the presence of air using up the oxidation inhibitors contained in the lubricants.

This causes sticking and noisy running until the high-temperature high-speed condition is attained. At extreme speeds, bearing-ring-to-retainer wear presents problems which suggested modification to reduce retainer whirl. At 125,000 r.p.m., failures tended to occur as a result of vibration.

Tests of bearings of 25-mm. bore at 540 deg. C. using powder lubricants such as metal-free phthalocyanine, lead oxide and a mixture of graphite and cadmium oxide gave good results. Bearing materials used in the high-temperature tests included tool steel, titanium carbide and materials of the stellite type. For retainers, Inconel-X gave good results sliding against titanium carbide, and stainless steel worked well against tool steel.

* A.S.M.E. Paper No. 58-LUB-10: "Accessory Manufacturer's Approach to Bearing and Seal Development".
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STAINLESS STEEL AS A STRUCTURAL MATERIAL

In the second part of this article the two steels FV.FSM.1 and FV.520 are considered for their suitability under specific conditions. Their design and production characteristics are examined, and the factors affecting selection are discussed

by I. L. G. BAILLIE, B.Sc., A.M.I.Mech.E.*

IN the first part of this article last month, two steels —FV.448 and FV.FDP—were described, and it was noted that, although one or the other could be used for a wide range of components, the difficulties in using these materials would be considerable and that improved materials are needed.

PUDDLE WELDING—The puddle welding process is worthy of comment, as it can be regarded as a major contribution to fabrication techniques which would be needed for designing structures in high-strength steel-sheet materials.

A tungsten electrode is used for puddle welding, and a shroud through which argon gas flows freely provides the normal inert atmospheric protection. The arc is struck on the outside face and a molten pool is formed; when the pool has penetrated part-way through the lower sheet, the arc is cut off, and the pool then solidifies (a gradual current decay rather than a sudden stop to the arc assists the weld quality). The process thus involves no pressure at any stage.

Control of the process is obtained by accurate timing and by regulation of the current. Material surfaces must be clean, and the gap at the interface should be virtually eliminated (up to about 0·002 in. gap is probably the maximum which should be tolerated). Welds can be produced in a variety of attitudes, and backing plates should be incorporated in the welding jigs whenever possible. The simplest weld is the shear joint shown in Fig. 3 for thin material and in Fig. 4 for thicker material.

Figs. 3 and 4 show the welded appearance of the face remote from the electrode; the "pip" on the back face guarantees good penetration and thus assists initial inspection. Fig. 5 shows an all-welded board (after grinding) typical of the accessibility problems which would be solved. Fig. 1 shows a different form of joint which can be used where the finish and strength are acceptable.

From the strength point of view, the puddle welding process can, under proper control, and with careful selection of welding currents, times, etc., provide welds with high static strengths in tension and shear. As shown by Fig. 2, the weakest zone is the parent sheet rather than in the weld nugget itself; this provides high energy absorption at failure and, therefore, good crack-stopping characteristics. The fatigue characteristics of puddle welds are believed to be very reasonable, provided penetrations into the lower sheet are not grossly inadequate.

The process can be adapted to give continuous runs, but peak-hardening or weld-softening effects (according to the materials involved) can then become more pronounced. Puddle welding is primarily intended for discrete welds, and in shear the general characteristics seem very suitable.

Austenitic (Unstabilised) Steel FV.FSM.1

To achieve greater work-hardenability in the 18/8 steels, low carbon 17/7 steels such as AISI type 301 were developed in the U.S.A.; these steels were unstabilised and therefore not always suitable for welding, even though the carbon was low. Replacement of some Ni by Mn and the retention of some nitrogen in solution in the austenite gave rise to a new steel AISI type 201.

Steels similar to AISI type 201 have now become available in this country, although development has to some extent been along slightly different lines, and a typical example is FV.FSM.1.

COMPARISON OF FV.FSM.1 WITH FV.FDP—FV.FSM.1 shows a greater strength for a given ductility than FV.FDP, and a lower proof/ultimate ratio; strength and formability are thereby both improved. Basically, the mechanical properties of FV.FSM.1 are similar to those of FV.FDP, so that many of the comments already made for FV.FDP apply also to FV.FSM.1.

In the 55/65 ton/in.^{2} strength range, FV.FSM.1 gives the longitudinal proof stresses lower than the transverse, as does FV.FDP; in the fully softened condition, FV.FSM.1 becomes isotropic, but if the strength is raised to around 75 tons/in.^{2} there is some evidence that the directional effect is reversed and that the longitudinal directional becomes the stronger, at least in tension.

HEAT TREATMENT TO IMPROVE E—FV.FSM.1, like FV.FDP, shows a low modulus in the cold rolled condition, and will show an improved modulus on heat treatment. As FV.FSM.1 is not stabilised against weld decay (intercrystalline corrosion at high temperatures), temperatures as high as 525 deg. C. for this heat treatment would be dangerous and lower temperatures need to be considered. Temperatures of 350-400 deg. C. for from two to 12 hours have been examined for 55/65 ton/in.^{2} material

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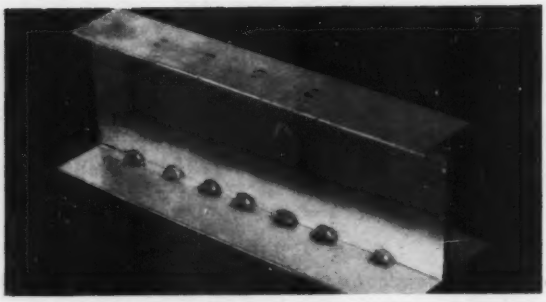


Fig. 1. Edge welding by the puddle welding process.

Fig. 2. Ductility of puddle welds as shown by prising.

and all found equally effective; 350 deg. C. for two hours therefore seems adequate.

The effect of the 350 deg. C. two-hour treatment was to improve the modulus and reduce the directional variations; unfortunately, drops in ultimate strength seem to occur and have been found to be as high at 12 per cent. For material in the 75 ton/in.^{2} condition temperatures around 400-450 deg. C. may be preferable, and there is a suggestion that at this strength the ultimate strength may not drop as a result of heat treatment.

Testing at elevated temperatures up to and above the heat treatment temperatures has shown that a significant drop in E occurs at around the heat-treatment temperature, but that otherwise the drops are similar to those for FV.FDP. However, this implies that the upper limit of temperature for FV.FSM.1 is lower than for FV.FDP, not merely because of lack of stabilising but also because of the drop in E at heat-treatment temperature.

Welding Properties—Because FV.FSM.1 is not stabilised against weld decay, it is not a suitable material for conventional welding processes. However, the carbon content is low and processes such as spot or "puddle" welding are satisfactory, provided the times at temperature are kept very low.

Simulation of brazing conditions showed that some softening occurred (ten min. to heat, then held for five min. at 750-1,200 deg. C.). Above 900 deg. C. the FV.FSM.1 was left with about the same strength as FV.FDP would have for the same ductility; the use of FV.FSM.1 rather than FV.FDP does not therefore seem attractive for high-temperature brazing. Below 900 deg. C. the advantage of FV.FSM.1 would depend on adequate demonstration that intercrystalline corrosion did not occur.

Forming and Assembly of Sheets—Due to the greater ductility for a given strength, FV.FSM.1 is potentially more suitable than FV.FDP for severe forming, and the strength range selected can depend on the degree of forming required.

For most severe forming, the fully softened or slightly cold-rolled conditions may be needed; for these conditions the material will probably not be initially flat, so that the forming operation will need to be so arranged that initial lack of flatness is eliminated during working.

If the forming operation will not be such as to eliminate lack of flatness, then the flatness will have to be provided during cold rolling; the minimum strength corresponding to good flatness seems to be around the 55-65 ton/in.^{2} range, with proof strengths of 35-45 tons/in.^{2} and elongations in excess of 25 per cent.

For less severe forming, higher strengths than these can be considered, with, of course, the usual associated drop in elongation.

Summary of Potentialities—FV.FSM.1 can best be regarded as a superior version of FV.FDP, giving either greater strength for the same formability or greater formability for the same strength. The limitations on welding need to be noted, however, and the lower temperature limitations. As with FV.FDP, FV.FSM.1 should be heat treated after forming to provide a general improvement in properties; FV.FSM.1, however, is unlike FV.FDP in that it does in some conditions of cold work show a drop in strength on this heat treatment.

Quasi-martensitic (Precipitation-hardening) Steel: FV.520

Major Characteristics—The hardening and tempering steels such as FV.448 are not suited to fabrication as they distort seriously if heat treated after forming, and are too hard and brittle to be formed after heat treatment. The cold-worked steels such as FV.FDP and FV.FSM.1 present corresponding problems as they need to be worked in the full strength condition and, apart from the low temperature treatments primarily intended to improve modulus, cannot be heat treated (after forming) to improve strength.

Thus, neither of the two conventional types of steels corresponds in forming characteristics to the well-known double heat treatment of aluminium alloys which can be formed soft (i.e., immediately after solutionising) and then be heat treated (i.e., precipitated) to provide full strength. Analogous characteristics in steels are now being achieved, however, and this new family of precipitation hardening (PH) steels offers several production advantages over the conventional types. FV.520 is a typical PH steel.

As with FV.FSM.1 in the modified 18/8 series, so with FV.520 in the PH series: the first marketed steels were American, but parallel development work in this country is now providing British steels with the improved properties.

Heat-treatment Procedures—The basic heat treatment sequence for FV.520 is as follows:

(i) supplied in the soft condition after sheet or strip rolling;
(ii) "transformed" by heating to around 700-750 deg. C. and cooled to room temperature (or preferably to around −10 deg. C. to reduce scaling);
(iii) "precipitated" by heating to around 450-550 deg. C. (the higher the temperature the lower the strength).

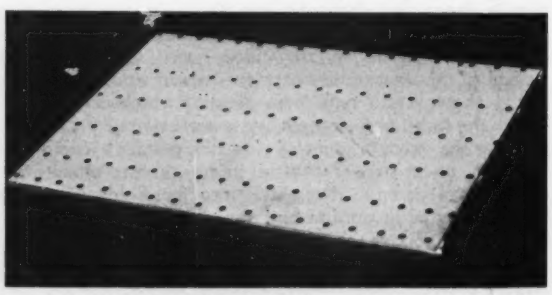


Fig. 3. Puddle welding of thin materials; as welded condition.

Thus, unlike the aluminium alloys mentioned above, the PH steel requires two heat treatments to achieve final strength after forming in the soft condition; it therefore corresponds to forming a double heat-treatable aluminium alloy in the annealed condition and following by solutionising and precipitation, except that after the first of the treatments the PH steel is hard and the aluminium alloy is soft.

FORMING AND ASSEMBLY—Provided FV.520 is fully worked in the soft condition and then fully heat treated without further forming, the properties after final heat treatment are virtually independent of the variations or degree of work in the softened state up to about 6 per cent strain.

Rectification of distortion after transformation heat treatment, however, can seriously affect properties after final precipitation; if the rectification produces more than 1 per cent or 2 per cent strain, the ratio of proof strength to ultimate strength in the final condition rapidly approaches unity and elongations become very low. Distortion and rectification problems therefore need special consideration. It should further be noted that any straining in the precipitated condition produces a very marked Bauschinger effect, so that manipulation of FV.520 after precipitation needs to be avoided.

A further problem with FV.520 is that there is a dimensional change of about +0·4 per cent during transformation; this is analogous to the dimensional change which occurs in aluminium alloys during precipitation but is about four times as large and may possibly vary with direction. This change could involve jigging difficulties as allowance for the subsequent dimensional change would be needed when designing jigs for forming soft; should the allowance not be correct, opportunities for rectification after transformation would be limited for reasons already stated.

WELDING PROPERTIES—FV.520 is capable of being welded by most processes in any heat-treatment condition, but the welded zone will be, as with FV.FDP and FV.FSM. 1, effectively soft. Assuming that welding prior to heat treatment is impractical, welding would need to be in the precipitated condition and the welds would therefore be subject to dimensional change if they were subsequently heated in service. The time for the change to occur would decrease with increasing temperature and for many high-temperature applications at least some transformation would occur. In this event either the structure would be severely distorted by the local strains at the welds or the welds would be so restrained by the structure that they might crack. It therefore appears that welding of FV.520 in structures liable to be heated may not prove satisfactory.

Brazing of FV.520 is a complex operation as the brazing temperatures and times interact with the heat-treatment cycles. By use of special brazing techniques and modified heat-treatment cycles, however, it appears that brazing of FV.520 could be a practical production process.

Steels dealt with in this part of article.

Type of Steel	Principal alloying elements	Strength obtained by	F.V. Code No.
Austenitic	17% Cr 4% Ni 6% Mn	Cold rolling	FV.FSM.1
Quasi-martensitic	17% Cr 5% Ni 2%Cu 2% Mo	Precipitation hardening	FV.520

MECHANICAL PROPERTIES—Compared with FV.FDP or FV.FSM.1, FV.520 shows less directional variation of mechanical properties; however, the longitudinal direction is the weaker and differences of 10 per cent between the two directions can occur, so that longitudinal rather than the conventional transverse testing would be preferable for material-control purposes.

So far as drops in properties at elevated temperatures are concerned, FV.520 occupies an intermediate position between FV.448 on the one hand and FV.FDP or FV.FSM.1 on the other. Apart from transformation difficulties associated with welds, therefore, FV.520 can be considered for high-temperature applications.

CORROSION PROPERTIES—FV.520 has been found to be considerably better than FV.448 in resisting accelerated stress-corrosion conditions, although for many applications FV.448 might from this aspect be adequate.

SUMMARY OF POTENTIALITIES—FV.520 represents an attempt to provide a stainless steel with heat-treating and forming characteristics more akin to those of double heat-treatment aluminium alloys. Although there are difficulties with FV.520 in terms of dimensional changes during heat treatment and of rectification effecting final properties, it could prove a superior material to FV.FDP or FV.FSM.1 for many applications and might, except where specific stiffness were of over-riding importance, also be superior to FV.448.

Future Development of Steel Sheet

It cannot be concealed that stainless steels, like other high-strength sheet materials, present many pitfalls to an unwary designer and that they are difficult materials to use in production. But the design advantages are considerable and, if the application warrants the production difficulties, then the full potentialities of strength, stiffness and corrosion resistance can be used.

The four materials described in these two articles are, of course, a somewhat arbitrary selection; there are others which may prove equally or more suitable for particular needs. The characteristics of all these materials are, however, not dissimilar and if, as is always desirable, the specialist advisory services of the material suppliers are fully used, and are allied to careful design and production control, these materials can be successfully employed.

The author wishes to thank Bristol Aircraft Ltd. for permission to publish this article, and to emphasise that the opinions expressed are his own and do not necessarily reflect the views of that company.

Fig. 4. Puddle welding of thick materials; as welded condition

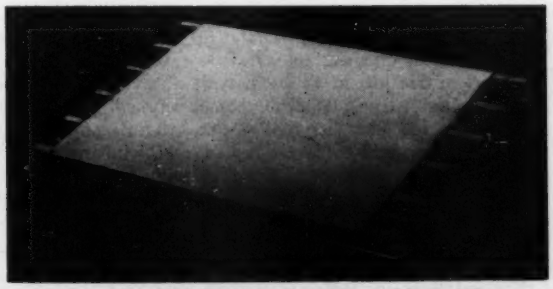


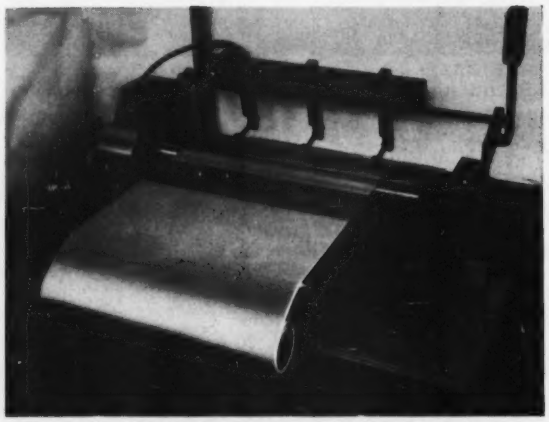
Fig. 5. All-welded board produced by puddle welding. Note difficulty of access which has been overcome.

L.T.E. IMPROVES REVERSER SWITCH INSULATION

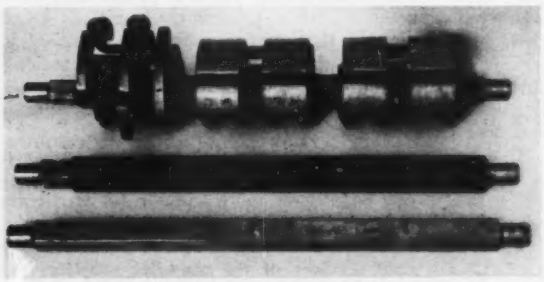
AN improved method of insulating the shaft on a traction motor reverser switch has been developed by London Transport's mechanical engineering department at Acton Works, where experiments have been carried on for several years with various types of electrical insulation as applied to London Transport rolling stock. Particular emphasis has been placed on silicone materials.

The switch drum used in the traction motor reverser switch is of the rotating drum type with contacts clamped to a square central shaft insulated for 600 V. Failure due to loose clamping caused by the shrinkage of the micafolium and shellac insulation in current use prompted investigation into other methods of insulating the shafts.

Initial experiments in applying the micafolium to the shaft in the normal way with a hot iron, but using a bakelised cement instead of shellac for the final application, proved unsuccessful, and shrinkage still occurred. It was then decided to discard the micafolium as the main insulating medium, and a composition of synthetic resin and mica dust was developed for application to the shaft in a specially-prepared mould. The trial shafts were given a final coating of anti-tracking paint and the contacts clamped directly on to the moulded insulation. This form of insulation proved perfectly satisfactory, both in mechanical strength and insulating properties, but difficulties in handling the compound retarded the production rate; it has also been shown from experience to be too hard to ensure the contact clamps gripping and remaining tight. These comparatively unsuccessful stages in the development were therefore quickly followed by further experiments using insulation in the form of a glass cloth wrapper impregnated with an epoxy resin which acts as an adhesive under heat and pressure. The glass cloth was obtained in roll form to suit the full width of the shaft, and the thirteen turns required to give the desired insulation thickness were wrapped by hand on the trial shafts. Following successful tests, it was then necessary to evolve a method of speeding up the process, and a special fixture was manufactured for the purpose. The glass cloth was fed under tension on to the shaft, which is rotated by a hand-operated ratchet device. As the shaft rotates, the heat and pressure required to activate the adhesive is applied by a hand-operated electrically-heated press head. When the desired number of turns is indicated on the counter attachment, the glass cloth is cut and sealed. The insulated shaft is then pressed between angle formers to ensure accurate dimensions, and placed in an oven to cure the epoxy resin. Finally, a coating of anti-tracking paint is applied to finish.



Fixture for applying glass cloth insulation, showing heater raised.



Assembled switch drum and shaft before and after insulation.

This form of insulation has proved most successful under severe service conditions, and many hundreds of reverser shafts are now being modified.

LETTER TO THE EDITOR

Sir,—Your November editorial calls for some comment.

I can understand that an analytical chemist, or perhaps a metallurgical chemist, may be too tied up in the technicalities of his job to keep up with materials in current use. This is not true of the competent physical or research metallurgist. . . . The secret of good materials engineering is wide reading and careful filing of useful information. I firmly believe that the metallurgist, with a broad background of study of a wide variety of materials, is the best candidate for the job of adviser to any design office. Unfortunately, the physical metallurgist is too useful carrying out works testing.

Industrialists are rarely technical men and thus often fail to realise that there is a world of difference between ability to find out what a material is composed of, and ability to visualise its application in a place where it has never before been used. But this is just what a physical metallurgist—who might know nothing of analysis—has been doing all the time!

Let's face it; we need materials engineers *now*. No other logical source exists, so why not try the physical metallurgist, provided he can be attracted away from research? Therein lies the main problem: there's a useful job for a man, but the metallurgical chemist is the man who moves to a productive industry, while the man who is needed moves to research. Some solution must be found.

Peter J. Allender

Solihull, Warwicks.

SINTERED ALUMINA CUTTING TOOLS

Ceramics are finding new applications in many fields of engineering; this article describes the present position of ceramic cutting tools which may ultimately influence the design of machine tools

by R. N. COOK*

OVER the years, various new tool materials have occasionally become available and we have seen steady development from the original carbon tool steels to high-speed steel, to carbides and now to sintered oxides. That is not to say that any one material necessarily supersedes its predecessor. It must be the responsibility of the production engineer to make best use of each of these individual materials according to the cutting conditions and the economics of each particular job.

The ideal properties of a tool material are high hardness, chemical inertness, high thermal conductivity, high compressive strength at elevated temperature and low thermal expansion. In addition to those materials mentioned above, a wide range of alternatives are provided for future investigation, by the carbides, oxides and borides of those metals in the 4th, 5th and 6th groups of the Periodic Table of Elements. Some of these materials, presented in descending order of hardness from the diamond, are: boron carbide; titanium boride; aluminium boride; silicon carbide; aluminium oxide; titanium carbide; tungsten carbide.

Attempts have been made to produce all these materials by various methods, but the basic problem is to produce an alloy which will give the range of requirements for a cutting material where hardness alone is not the sole criterion. Aluminium oxide at present seems to offer some prospect of achieving this aim.

The experimental use of tools made from a material that is basically aluminium oxide goes back to the early 1930s. It was the last war which stimulated further research and development into the possibilities of this tool material, since manufacture of tungsten carbides employed strategic raw materials which might have become impossible to obtain. However, these raw materials did not become seriously short during the war and the urgency for further development work on oxide tooling disappeared.

* *Research and development manager, Wimet division, Wickman Ltd.*

Interest was restimulated at the Chicago Fair in 1954. Here, demonstrations with such tools were made, mainly as a machine tool sales attraction, and were therefore accorded considerable publicity. Materials which are basically aluminium oxide have acquired many different names, but the definition "keramic" or "ceramic" is not accurate enough to define the type of material which is processed specifically for use as a cutting tool.

Although ceramics, in the widest sense of the term, can be used for cutting steels, their performance will be considerably inferior to that of materials sintered and mixed with metallic carbides, these latter having very high resistance to cratering and enabling much higher cutting speeds to be achieved. Carbides, if properly applied, already adequately cover speeds up to 1,000 f.p.m. on steels.

High cutting speeds in themselves do not necessarily guarantee increased production rates. Of the total floor-to-floor time in any machining operation one has to consider the loading and unloading of the component, with the setting and operation of the machine by the operator. There is therefore little to be gained by substantially increasing cutting speeds over 1,000 f.p.m. unless mechanical loading and off-loading of the component is employed, combined with tape or other automatic means of control for the machine tool itself. Nevertheless, experiments have been carried out with Wimet grade SO sintered oxide up to cutting speeds of 26,000 f.p.m. on steel.

The relative properties of sintered oxide compared with tool materials in general use today are shown in Table 1, while Table 2 shows the types of wear and deterioration experienced in cutting tools and the physical properties demanded from the material in order to overcome or minimise the wear.

With the notable exception of aluminium alloys, sintered oxide cutting tools can be applied on most steels and non-ferrous alloys. Optimum tool life for sintered oxides is obtained with negative rake angles greater than those

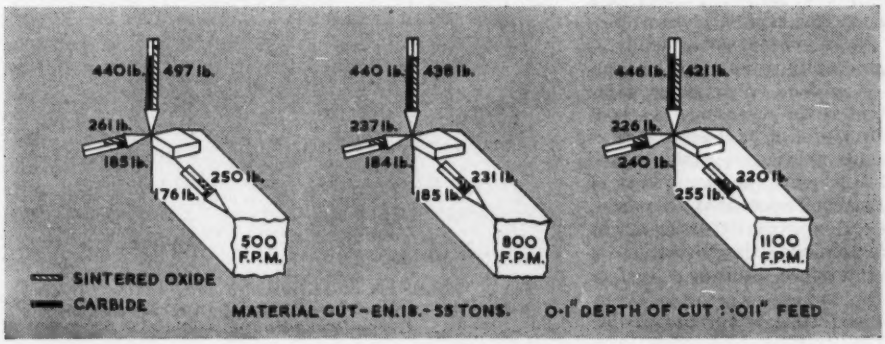


Fig. 1. Loads on carbide and sintered oxide tools at various cutting speeds.

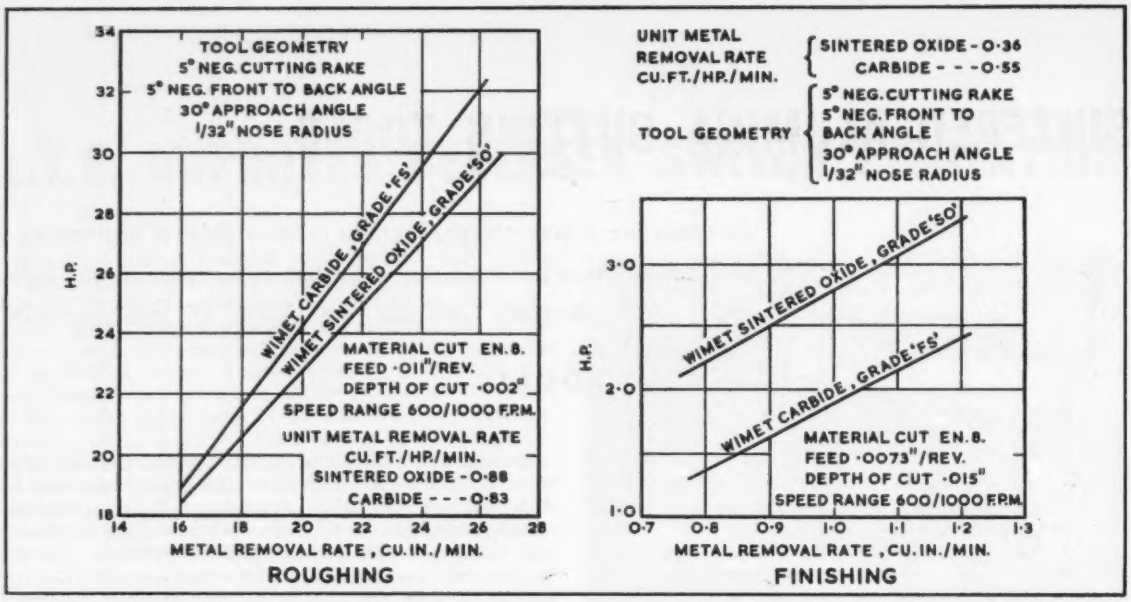


Fig. 2. Comparison of the relative performances of oxides and carbides on the basis of metal-removing efficiency.

usually associated with carbide tools. However, it may be considered worth while to accept a loss of optimum life for the advantage of making tips interchangeable within the tool holders designed for carbide tips. It should be remembered that often a carbide tool is already exploiting the power availability of the machine tool to the full and that the additional requirements for further negative rake would not be available anyway.

Experience with carbide tools has shown that it is helpful to stone off the sharpness of the cutting edge, and with oxide tools it is imperative to carry out this operation, not only along that part of the edge which is actually in cut, but throughout the whole length of the cutting edge.

Oxide tips are usually clamped in mechanical holders using tips $\frac{1}{2}$ in. sq. × $\frac{3}{16}$ in. thick. Such tips provide eight cutting edges which can readily be changed, but where space considerations do not permit clamping it is possible to carry out brazing or bonding operations.

Using the established clamped tip geometry for carbides, of 5 deg. negative rake, 5 deg. front to back angle and $\frac{1}{32}$-in. nose radius, the actual cutting forces approximate to those for carbides, when the oxide is being operated at somewhere near its optimum speed (Fig. 1).

Present indications are that oxides will be complementary to carbides and can immediately find a small field of application on modern machine tools for high-speed finishing cuts. How large the field of application ultimately becomes will depend entirely on the progress made in machine tool design, and to any further metallurgical developments found possible to enhance the physical properties of oxide material.

It is well known that high cutting speeds usually show an improvement in *observed* surface finish. Since oxide can operate at high speed and at the same time has considerable resistance to the formation of built-up edge, it is sometimes possible to produce finishes of such a good surface character as to make possible the elimination of subsequent grinding or burnishing operations. However, at speeds within their scope and on material which can be cut under conditions which minimise the formation of built-up edge, carbides can produce equivalent surface finish (Fig. 5).

A great deal has yet to be learnt about the precise mechanism and types of wear associated with sintered oxide tooling. There is no doubt that the flank wear land is more difficult to measure. Under some conditions an "apparent" wear land is produced. This appears to be a film, possibly of iron oxide, which must be dissolved off in hot caustic solution before it is possible to see and measure the true wear land. It may be lack of appreciation of this fact which explains why wear lands up to 0·060 in. have been reported for some sintered oxide tools. In this case it is probably the "apparent" wear land which has been measured, when in fact the true wear land would probably be somewhere near half the amount.

From work carried out so far, it is evident that in the

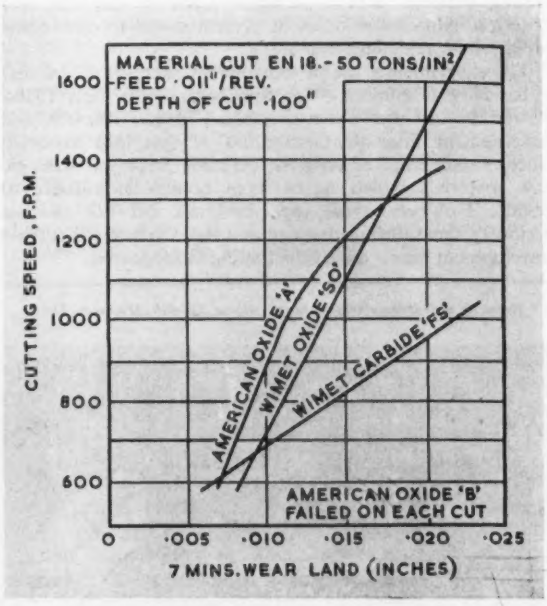


Fig. 3. Comparison of performance between the hardest grade of tungsten carbide (FS) and three sintered oxide tools.

speed range up to 2,000 f.p.m. chip control is not too difficult where the speed and depth of cut are reasonable. The proportions established over the years for chip grooves in carbide cutting edges are, in general, applicable at these speeds.

Research at speeds over 2,000 f.p.m. is not urgent, as the problem will not arise until machine tools are generally capable of these speeds on small diameters.

The sintered aluminium oxides made by different manufacturers seem to vary widely in their resistance to the action of a diamond cutting wheel, probably because these oxides vary in terms of their overall hardnesses.

From experiments carried out the following recommendations may be made:

(i) It is essential to grind wet. In all cases an excess of coolant should be present, preferably applied to the wheel centrifugally. Dry grinding causes burning of resinoid bonded wheels, which in turn causes chipping of the cutting edges. With metal bonded wheels, dry grinding promotes the generation of excessive heat and this will also cause chipping of the oxide.

(ii) Resinoid bonded wheels cut faster and more freely than metal bonded wheels.

(iii) Gravity feed will provide sharp edges even when grinding away from the cutting edge as well as towards the edge. Fixed feed grinding will also give chip-free edges, provided that the relative movement between the wheel and the work is slow enough to allow sparking out to take place.

(iv) Where a slower rate of stock removal can be accepted, metal bonded wheels may be used with equal success, provided adequate dressing is maintained and pressures kept to a minimum.

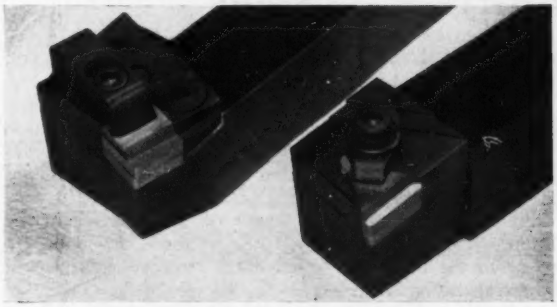


Fig. 4. Clamptip tools for tungsten carbide or sintered oxide tip. (Solid carbide anvil under tip; solid carbide chipbreaker on top.)

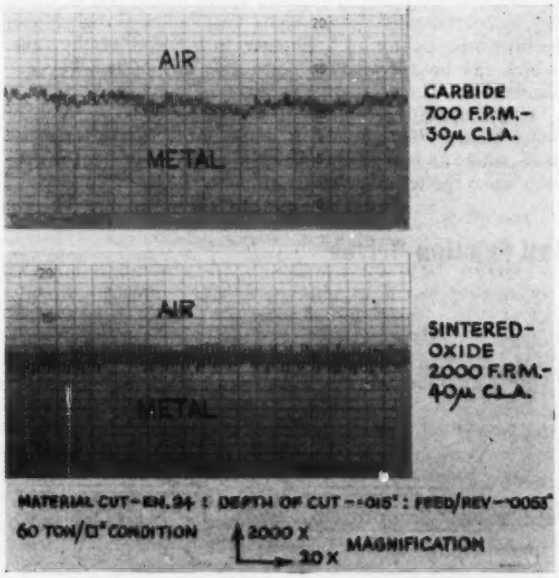


Fig. 5. Comparison of surface finish obtained with carbide and sintered oxide tools.

TABLE 1—Relative properties of sintered oxide and other tool material s

Tool Material	Hardness V.P.N.			Transverse Rupture Strength p.s.i.	Young's Modulus p.s.i.	Coeff. of Thermal Conductivity C.G.S. Units	Coeff. of Thermal Expansion per °C.
	Room Temp.	600° C.	800° C.				
Carbon steel	700-900	200	100		30×10^6	0.14	14.7×10^{-6}
High Speed Steel	650-800	600-700	200	400×10^3	32.5×10^6	0.061	12.8×10^{-6}
Cast cobalt based alloy	600			$150-180\times10^3$	30×10^6		$14.5-16.9\times10^{-6}$
Tungsten carbide cobalt	1200-1800	1000-1200	700-900	$150-350\times10^3$	$75-88\times10^6$	0.19	$4.8-6.0\times10^{-6}$
Tungsten-titanium carbide cobalt	1200-1800	1100-1250	900-1000	$120-250\times10^3$	$70-75\times10^6$	0.09-0.15	$5.0-7.0\times10^{-6}$
Sintered Oxide	1500-1800			$35-90\times10^3$	50×10^6	0.056	7×10^{-6}

TABLE 2—Wear resistance needed in tool materials

Type of wear or deterioration	Properties required in tool material
Flank wear	High hardness. Chemical inertness.
Cratering	Chemical inertness.
Build up	Chemical inertness.
Deformation	High compressive strength at high temperatures. Chemical inertness. High thermal conductivity.
Fracture due to mechanical stress	Toughness.
Cracking due to thermal stresses	High thermal conductivity. Low thermal expansion. High tensile strength. Low Young's Modulus.

A standard test rig is employed to check the stock removal rates, both initial and sustained, of various types of wheel. The apparatus employs test pieces $\frac{1}{4}$ in. square which are pressed on to an oscillating wheel under a gravity load of 5 lb.

A resinoid bonded wheel, reference D200-50-B4-1/16, removed the following amount of material from the test piece:

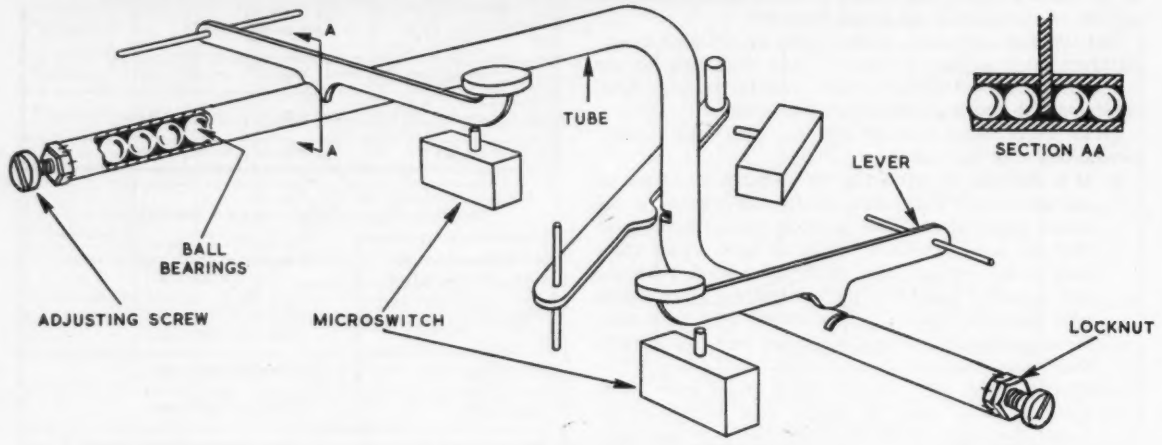
Wimet "N" Carbide	...	...	0·025 in./min.
Wimet SO Oxide	...	...	0·050 in./min.
Oxide "A"	...	...	0·090 in./min.

Under the same conditions a metal-bonded 120/160 diamond wheel removed 0·018 in. in the same time and was reasonably consistent on all three materials.

There is no doubt that sintered oxides provide a useful addition to the present range of tool materials. Coupled with the improvements continually being made in sintered carbides, there is now an urgent need for progress in machine tool design.

From present knowledge the field of application for oxides appears to be in the speed ranges beyond those normally catered for by carbides at the present time, the cutting loads at these higher speeds not necessarily exceeding those within the capacity of carbides. As higher cutting speeds are made possible by the use of alternative cutting materials, not necessarily either carbides or oxides, so the power required to remove metal faster imposes conditions which the machine tool designer will require to meet.

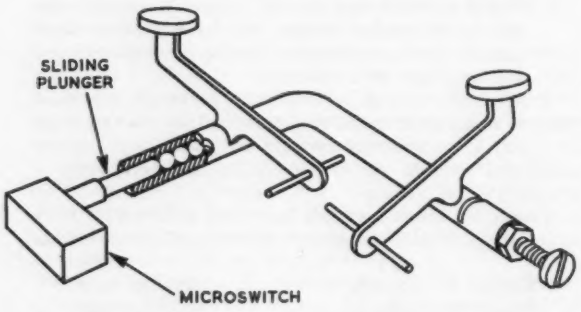
designer's notebook



Method of Interlocking Independent Levers on a Machine

IN many different kinds of mechanical and electro-mechanical equipment it is sometimes necessary to prevent the operation of more than one lever at a time. The levers may be widely spaced apart on the machine, and the axes of the shafts on which they operate may be in different planes.

It may, for example, be necessary to provide for the operation of only one key at a time on an office machine. Alternatively, the operators of two machines side by side, only one of which should be started at a given moment, must be provided with a foolproof device.



A simple device which can be easily adapted to many different situations is illustrated *above*, in an application where the operation of only one of three microswitches must occur. A metal tube, fitted with ball bearings, is fitted at each end with an adjusting screw and locknut.

At the points along the length of the tube where the levers are situated, and in line with them, saw cuts are made in the tube into which fits a radiused enlargement of the operating lever.

Adjusting screws are provided to position the balls in the right relationship to the microswitch operating levers. The balls are adjusted so that only one lever can be operated at a time.

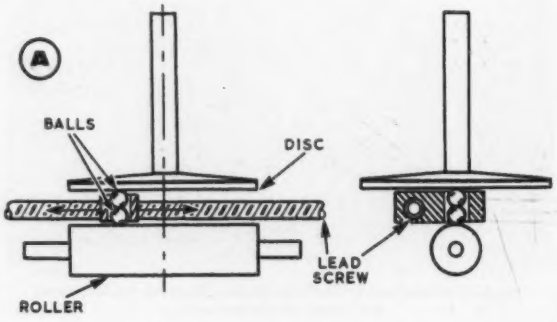
The type of application shown *above* is only one of many possible arrangements. In some cases a microswitch can be operated by fitting a plunger to the end of the tube, which can be operated by depressing one of two keys, as shown *left*.

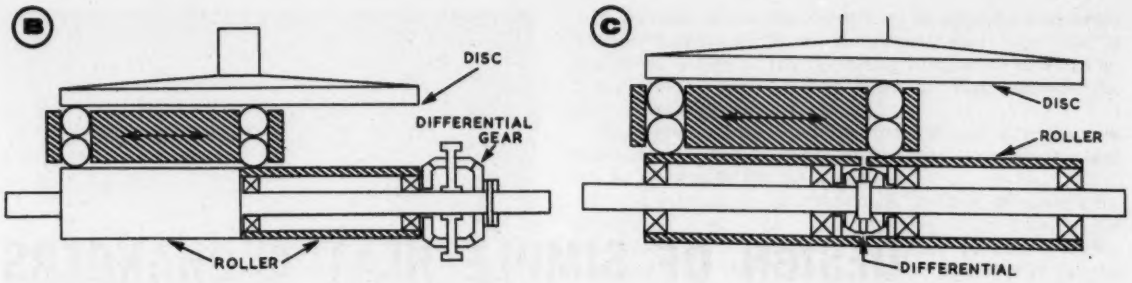
If the operating lever is to be subjected to a force of more than a few pounds, it is advisable to reinforce the tube where it has been slotted, in order to prevent distortion when the lever is depressed.

An Improvement to Ball Friction Drives

A FEATURE commonly found in mechanical integrators is the ball and disc drive, which provides an infinitely variable speed-gear. The working principle of such a drive is shown diagrammatically *right*. A cage containing two balls is made to pass across the face of a revolving disc by the rotation of a lead screw and transmit drive to a roller via the balls. In such drives it is common practice for the hardened and lapped roller to be spring loaded to hold the balls in positive contact with the disc. The balls make rolling contact with both disc and roller, and a positive drive is provided until the balls reach the middle of the disc.

If, however, it is a necessary feature of the instrument that the balls pass across the axis of rotation of the disc,

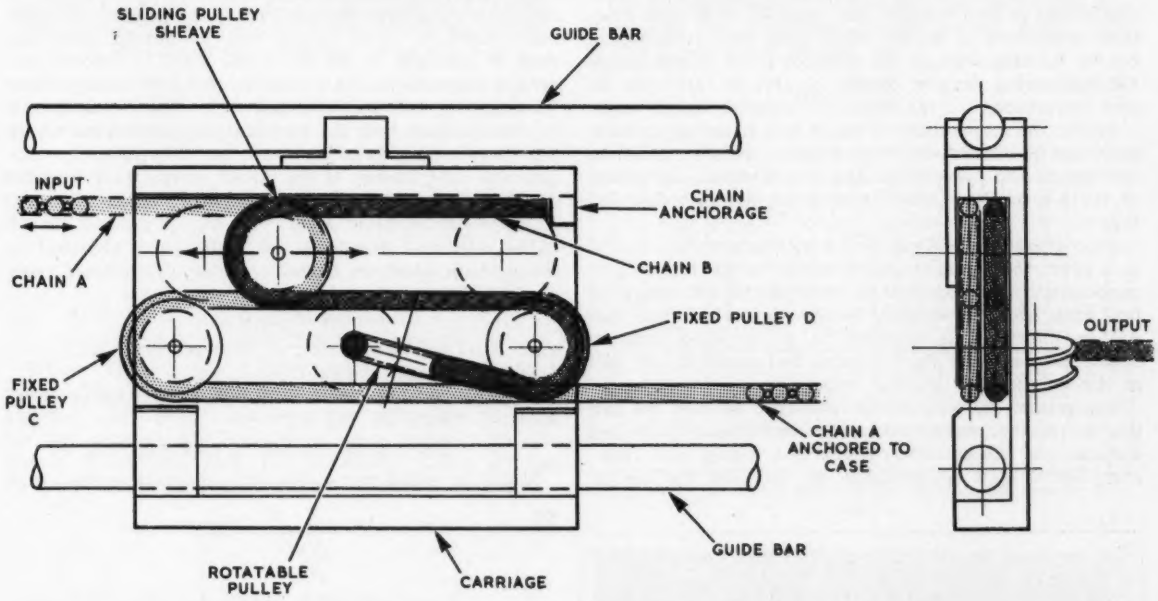




where direction of drive is reversed, an unsatisfactory feature is that scuffing of the balls occurs. A further poor feature is that one-sided loading of the disc gives rise to bearing trouble.

By the introduction of a differential gear, several alternative arrangements are possible, which obviate the disadvantages mentioned, by providing positive drive at all times, with smooth reversal. Two possible types of layout are shown *above*. In each of these it will be seen that two pairs of balls in a common cage are used. These traverse the face of the disc and cause left- and right-hand rotation of the roller, which is in two halves, drive being taken by a differential gear to the output shaft. With this arrangement it will be seen that, when each pair of balls is equi-distant from the axis of the disc, the rotation of the two halves of the roller will be at the same speed but in opposite directions, and the output shaft will not rotate. Thus, from maximum to minimum reduction, through the point of no transmission to full speed reversal, drive is positive at all times. This idea forms the basis of an invention for use in a navigational instrument for which a patent application has been made.

Ingenious Use of Ball-chain in a Navigational Instrument



IN a navigational aid it was necessary to provide a means of operating a lever situated in an instrument mounted on a moving carriage. An additional difficulty to be overcome was that the lever to be operated moved in an arcuate path about the centre line of the carriage when viewed in plan. It was decided, therefore, to make use of light ball-chain which can be passed over pulleys whose axes are in a number of different planes. An additional advantage of such chain is that it can be passed over pulleys of smaller diameter than a cable without setting or kinking.

The method of transmitting movement to the lever is shown in the diagrammatic simplified drawing, the actual lever and the instrument of which it formed a part being omitted. To the carriage, which slides on two guide bars, are fitted two fixed pulley sheaves and a sliding sheave containing two pulleys. The ball-chain A passes round the lower pulley in the sliding pulley sheave, then round the fixed pulley C and is anchored to the side of the case of the machine. Ball-chain B, anchored to the side of the moving carriage, passes round the upper pulley in the sliding sheave, round the upper pulley in the fixed pulley block D and thence round the rotatable pulley to the lever to be operated in the instrument.

Input signals, by shortening or lengthening the chain A (which is maintained in a constant state of tension), cause lateral movement of the sliding pulley sheave and in so doing cause equivalent lengthening or shortening of chain B, regardless of where the carriage is situated on the guide bars. Although this invention was devised for a light instrument application, it appears to offer interesting possibilities in other engineering fields.

DESIGN OF SIMPLE HEAT EXCHANGERS

For the engineering designer who may be called on to design a simple heat exchanger, this article provides an introduction and a guide to the calculations that will be required

by R. W. NEW, Assoc.M.C.T.

ALTHOUGH the design of heat-transfer equipment is a subject for the specialist, engineers occasionally require to design a simple form of heat exchanger where precise performance is not essential.

The calculations of heat flow, rates of heat transference, coefficients of heat transfer, etc., together with their practical application to design, often seem very complicated, but by working through the example given in this article the engineering designer should be able to carry out his own calculations for the design of relatively simple units.

Briefly, the mechanisms by which heat transmission takes place can be divided into three groups: namely, radiation, conduction and convection. The last of these, convection or, more precisely, "forced" convection, will be considered here.

HEAT FLOW—Heat flows from a high-temperature source to a lower temperature source, and it is this property of temperature difference that is employed in the design of heat exchangers. In deciding on the manner in which this will be utilised, it is desirable, as in any other field of engineering, to take into account the economics as well as the technicalities of heat transfer.

The greater the temperature difference between the two heat sources the smaller must be the area of heat-transferring surfaces, and this ultimately results in a smaller unit. However, where high temperatures are involved the use of cheap engineering materials may not be practicable.

Another way in which the size of the heat exchangers may be reduced is by making use of high velocities of the fluid through the tube bundles. However, higher velocities result in correspondingly larger pressure drops which, in turn, require greater horsepower at the pumps. A direct consequence of these factors will be heavier operating costs in addition to greater initial cost; it follows that careful judgment on the part of the designer is required.

INLET AND OUTLET TEMPERATURES—The problem may be one in which both the inlet and outlet temperatures of the "cold" fluid, together with the flow quantity, are specified. The choice of the "hot" source may also be specified, and could well be waste steam at low pressure, or waste contaminated water.

The total heat flow from the "hot" source absorbed in raising the temperature of the "cold" fluid is obtained from the following:

$$H = w.c_p.\Delta t \qquad (1)$$

where H = heat gained by cold fluid per hour, B.t.u.;
w = weight of cold fluid, lb./hr.;
c_p = mean specific heat of fluid at constant pressure, B.t.u./lb. deg. F.;
Δt = temperature increase of cold fluid, deg. F.

It will be noted that c_p has been specified as the mean

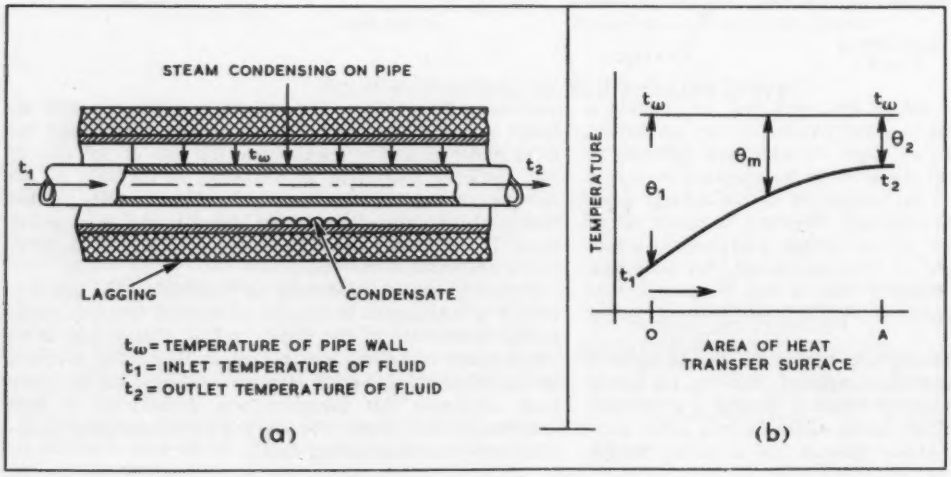


Fig. 1. Mean temperature difference in a simple heat exchanger.

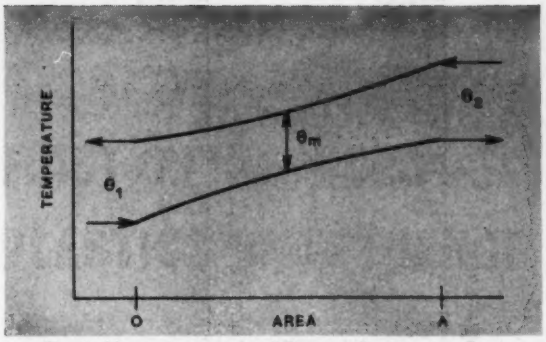


Fig. 2. Mean temperature difference for counter flow.

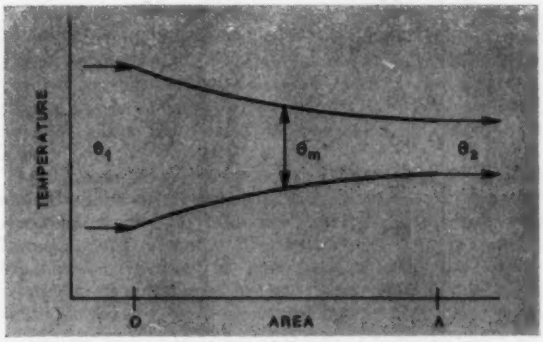


Fig. 3. Mean temperature difference for parallel flow.

specific heat. Particular care may have to be taken, as it may show a fairly substantial variation over the range of temperatures encountered during the heating process.

ACTUAL TRANSFER OF HEAT.—Having previously determined the total heat required, it is necessary to consider the actual transfer of heat from the pipe wall to the fluid flowing through the pipe:

$$H = h.A.\ \theta_m \qquad (2)$$

where h = heat transfer coefficient, B.t.u./hr./ft.^{2}/deg. F. temperature difference;
A = area of heat transfer surface, ft.^{2};
θ_m = mean temperature difference, deg. F.

MEAN TEMPERATURE DIFFERENCE—The arithmetical mean temperature difference between the heating source and the "cold" fluid is not, as a rule, sufficiently accurate for this purpose; the logarithmic mean temperature difference is normally used. The derivation of this will not be given but the formula is simply quoted:

$$\theta_m = \frac{\theta_1 - \theta_2}{\log_e \frac{\theta_1}{\theta_2}} \qquad (3)$$

where θ_1 = initial temperature difference, deg. F.;
θ_2 = final temperature difference, deg. F.

For the purpose of clarity, θ_1, θ_2 and θ_m are illustrated diagrammatically in Figs. 1, 2 and 3. Fig. 1(a) illustrates a simple heat exchanger in which steam condenses on the outer surface of the inner tube. With steam heating of this type, the rate of heat transfer from the steam to the pipe is usually very high when compared with that from the pipe to the "cold" fluid. For this reason we assume that the temperature of the pipe wall remains substantially constant at t_w. The fluid flows from left to right as indicated by the arrows, with an inlet temperature of t_1 and an outlet temperature of t_2.

$$\theta_1 = t_w - t_1$$
and $$\theta_2 = t_w - t_2$$

Figs. 2 and 3 represent the cases where a "hot" fluid flows in the annulus between the outer and inner pipe.

In the case where the fluids flow in opposite directions, the heat exchanger is of the counter-flow type, and is illustrated in Fig. 2. The remaining case, illustrated in Fig. 3, is known as parallel flow when the fluids flow in the same direction.

We assume in this instance that the unit is sufficiently well lagged so that losses to atmosphere are negligible and can be ignored in the calculations.

In the example to be considered, the case of steam condensing is used. The two remaining cases require the calculation of an "overall" coefficient of heat transfer, involving h for the "hot" fluid to the pipe and H for the pipe to the "cold" fluid. This calculation is beyond the scope of the present article.

For engineers who prefer a graphical aid in determining θ_m, the nomogram in Fig. 6 may be used. A straight line is drawn from θ_1 to θ_2 on the two outer scales, and θ_m is read off at the intersection of this line with the centre scale.

CALCULATION OF HEAT-TRANSFER COEFFICIENT—In the case of water flowing through a pipe, the heat-transfer coefficient, h, may be calculated from the following formula:

$$h = 150\ (1 + 0{\cdot}011\ t)\ \frac{V^{0{\cdot}8}}{D^{0{\cdot}2}} \qquad (4)$$

where t = temperature of fluid, deg. F.;
V = velocity of fluid, ft./sec.;
D = diameter of pipe, in.

The Reynolds number in the pipe must not be less than 2,100 and for preference should exceed 4,000. The Reynolds number is defined as:

$$R = \frac{v.d.\ \rho}{\mu} \qquad (5)$$

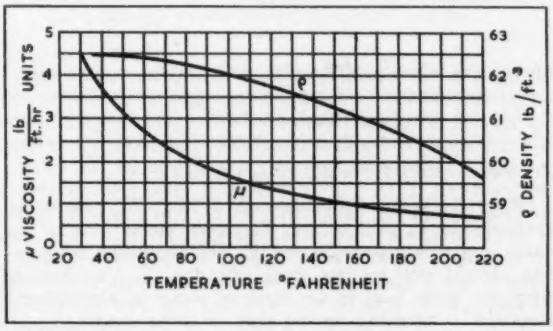


Fig. 4. Effect of temperature on viscosity and density of water.

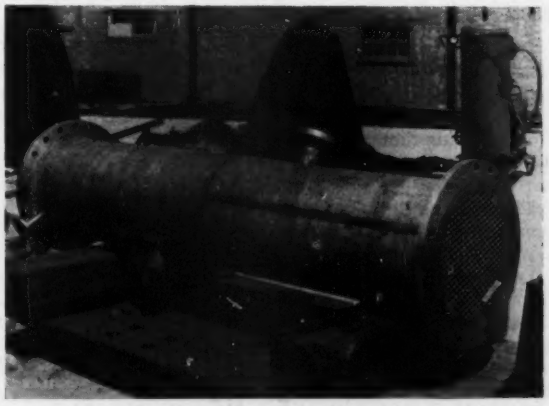


Fig. 5. Simplest type of heat exchanger, with one tube pass and one shell pass.

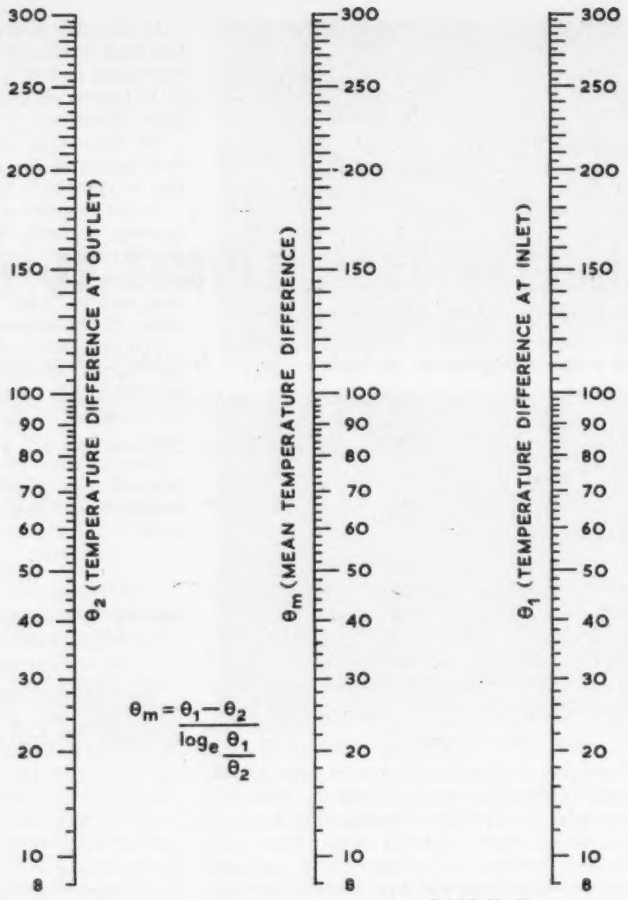


Fig. 6. Nomogram for determining θ_m. A straight line is drawn from θ_1 to θ_2 on the two outer scales, and θ_m is read off at the intersection of this line with the centre scale.

where v = velocity of fluid, ft./hr.;
d = diameter of pipe, ft.;
ρ = density of fluid, lb./ft.^{3};
μ = absolute viscosity, lb./hr. ft. units.

Values ρ and μ for water are given in Fig. 4.

EXAMPLE—Water flows through a 1-in. dia. pipe at an average velocity of 2 ft./sec. The inlet temperature of the water is approximately 50 deg. F., and the outlet temperature should not be less than 120 deg. F. For heating purposes, waste heat in the form of steam at atmospheric pressures, condensing on the pipe, is to be used.

Estimate the total heat transferred per hour and the length of pipe required as follows:

The temperature of the pipe is assumed to be substantially constant at 200 deg. F.

$$\theta_1 = 200 - 50$$
$$= 150 \text{ deg. F.}$$
$$\theta_2 = 200 - 120$$
$$= 80 \text{ deg. F.}$$

Substituting these values in Formula (3), or reading from the nomogram, we obtain:

$$\theta_m = 111{\cdot}3 \text{ deg. F.}$$

Therefore, mean water temperature, t_m

$$= 200 - 111{\cdot}3$$
$$= 88{\cdot}7 \text{ deg. F.}$$

Density of water at 88·7 deg. F.

$$= 62 \text{ lb./ft.}^3 \text{ approx.}$$

Weight of water, w, flowing through pipe

$$= V.A_1.\rho. \text{ 3,600 lb./hr.}$$

where A_1 = cross-sectional area of pipe, ft.^{2}

Therefore,
$$w = 2 \times \frac{\pi}{4} \times \frac{(1)^2}{144} \times 62 \times 3{,}600$$
$$= 2{,}435 \text{ lb./hr.}$$

Now from Formula (1), and taking c_p as unity, we obtain

$$H = 2{,}435 \times 1 \times (120 - 50)$$
$$= 170{,}450 \text{ B.t.u./hr.}$$

To find h, subsitute the appropriate data in Formula (4):

$$h = 150 \times (1 + 0{\cdot}011 \times 88{\cdot}7) \times \frac{2^{0{\cdot}8}}{1^{0{\cdot}2}}$$
$$= 516$$

Rearranging Formula (2) in terms of surface area:

$$A = \frac{H}{h \cdot \theta_m} \qquad \textbf{(2a)}$$

Substituting in (2a) known values,

$$A = \frac{170{,}450}{516 \times 111{\cdot}3}$$
$$= 3 \text{ ft.}^2 \text{ approx.}$$

Now,
$$L = \frac{12A}{\pi D}$$

where L = length of pipe, ft.

Therefore,
$$L = \frac{12 \times 3}{\pi \times 1}$$
$$= 11{\cdot}45 \text{ ft.}$$

This length of pipe could be divided into several smaller lengths comprising, in effect, several small heat exchangers coupled together in series. Alternative methods exist which would enable a smaller heat exchanger to be used, but its calculation is beyond the scope of this article.

FIRST REINFORCED PLASTICS CONFERENCE

SEVERAL of the many scientific papers presented at the recent Reinforced Plastics Technical Conference, arranged by the British Plastics Federation at Brighton, indicated what may well be a landmark in the development of resins and reinforcements and the technique of fabrication.

The investigation into the possibilities of a flake glass laminate is of signal importance since, in theory, it would overcome many of the disadvantages associated with fibrous reinforcements. The advantages are the multidirectional properties as contrasted to the uni- or bidirectional properties of woven fibres and the ability to pack the flakes closely and thus avoid the present large voids, necessitating a high proportion of resin. Stronger adhesive bonds result and, it is reasoned, the flakes would be cheaper to produce than the fibres. Experimental work is still in hand by the Picatinny Arsenal in the U.S.A., and there is little doubt that this type of reinforced plastic will be very much to the fore in the near future.

Much criticism was made at the conference of the hand lay-up method used in the fabrication of parts in reinforced plastics and, as one speaker suggested, the aim should be to eliminate chemistry from the engineering shops. In this respect, the properties and applications of dough mouldings (British Resin Products Ltd.) is significant. While at the present more expensive than general-purpose phenolics, they offer the advantages of a ready-to-mould compound with low moulding pressures and rapid cure for the present main disadvantages of a limited life during storage before curing.

Pre-impregnated reinforced plastics employing the usual types of resins, such as polyesters, diallylphthalates, phenolics, epoxies, etc., also offer some hope of achieving automation to take the place of hand lay-up methods. The reinforcing media may be chosen from any of the established fabrics such as glass fibres, asbestos, paper, nylon, etc. The acceptance of pre-impregnation should lead to a considerable increase in the applications of reinforced plastics, since it will be possible to apply modern fabrication techniques to these materials.

Simultaneous Deposition

A different approach towards automation is offered by the Rand Spray-up process, whereby the reinforcement and the newly activated resin are simultaneously deposited by a special spray gun. This process has considerable potentialities and has been satisfactorily used in the construction of swimming-pools by spraying directly on to the freshly-dug earth. Boat hulls provide another example of this technique being used successfully. The equipment needed for the Rand Spray-up process is being handled in this country by Lawrence & Erausquin (U.K.) Ltd., who will be staging a demonstration in the near future. This process may well reduce the cost of constructing ponds associated with cooling towers.

Photo: Lawrence & Erausquin (U.K.) Ltd.

Rand spray-up process in operation, showing simultaneous deposition of reinforcement (glass fibre) and resin.

One of the particular problems facing the industry is the need for reinforced plastics to work at elevated temperatures with low creep values and a high resistance to fatigue. To this end, research is being conducted by the R.A.E. at Farnborough and by individual firms, as evidenced by papers presented by Dr. R. B. Heywood of the R.A.E. and Mr. A. W. Thompson of Bristol Aircraft Ltd., the latter showing that glass fibre laminates have a strength retention in fatigue considerably higher than aluminium alloys and certain steels. While creep is continuous for very low loadings, its rate may be regarded as insignificant.

Dr. Heywood's investigations covered the effect of finish on glass fibres, the effect of various types of weave and the stresses which may arise due to the volumetric contraction of various resins. In common with other speakers, Dr. Heywood stressed the need for obtaining comparable data on reinforced plastics and suggested that fatigue-testing machines need to be redesigned to meet the particular requirements of reinforced plastics.

The use of these plastics for fireproof containers or bulkheads is an attractive proposition, but more development work is needed in order that they will fulfil the stringent conditions, and at the same time show a saving in weight over their metal counterparts. Several interesting approaches to this problem are being investigated and there is little doubt that time will produce the desired result.

The principal applications in the electrical industry of silicone resin glass cloth laminates have been in the insulation field, though some mechanical applications have also been found, mainly in aircraft component construction. Features which favour the electrical applications of these laminates include good dielectric properties which are retained over a wide frequency and temperature range, and

excellent thermal endurance. This has helped considerably in the design of high-temperature, lightweight radio transmitters and other airborne electrical apparatus. Other applications have occurred in the insulation of a variety of modern electrical equipment, including dry-type distribution transformers, dielectric heating equipment and domestic convector heaters. Limitations to the still wider use of silicone resin/glass cloth laminates in the electrical industry are chiefly high price and poorer mechanical properties than most organic resin/glass cloth laminates.

The chemical industry is a potential user of reinforced plastics, but in common with most industries it is reluctant to take for granted the long-term properties of plastics, and from this there is an obvious need for accelerated tests to evaluate the properties of reinforced plastics over a long period.

Similar problems face the manufacturers of lifeboats in this material, although many boats are at present in use and show every sign of having a long life free from maintenance. In the new P. & O. liner, *Canberra*, large-scale employment of reinforced plastics is envisaged, both internally and externally. The use of reinforced plastics tanks for long-term storage of drinking water and the effect of micro-organisms are being investigated by Microcell Ltd. This factor is of particular importance in lifeboats, where the water tanks may be integral with the hull.

Dr. F. Jaray suggested Continental manufacturers appeared to be in advance of the U.K. in the production of road tankers in laminated plastics (see photograph this page).

Aircraft Industry

In the aircraft industry the use of reinforced plastics is increasing. For example, the Vickers Viscount used 88 components of this material, and the Vanguard 1,400 parts, while in the new VC.10 upwards of 2,000 such components are visualised.

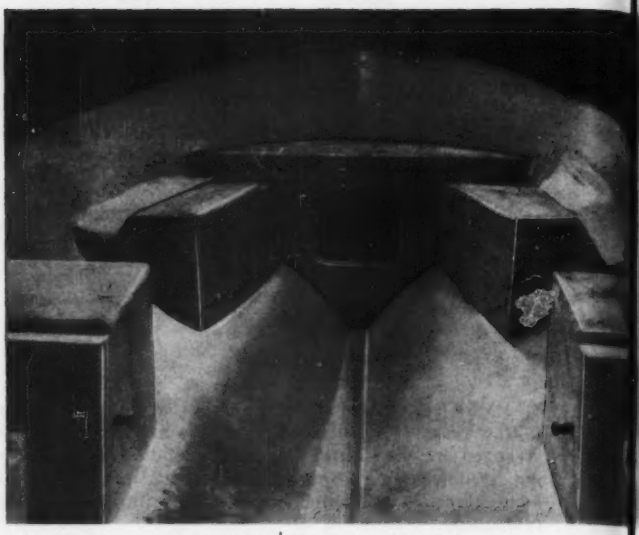
B.P. Exploration Co. Ltd. are at present using helicopters to transport steel pipes and drilling equipment into thickly-wooded countries for trial borings; here the use of reinforced plastic pipes would be of great advantage, since the weight of the steel pipes causes difficulty in handling. Another use for this form of pipe is where the trial bores pass through a coal seam; here steel pipes may not be used, as they would cause damage to the machinery eventually used in coal cutting.

The use of reinforced plastics for bridge pontoons indicates the interest taken in this material by the military authorities, and it may be visualised that their use may be extended to other structures associated with the engineering side of the fighting services.

Both the British Transport Commission and the London Transport Executive are actively considering uses for

Photo: N.V. Motorkracht

Long-distance milk tanker consisting of three glass-fibre reinforced tanks covered by a single insulating shield.



Mechans Armarine standard lifeboat, showing fabric reinforcement strips used in bonding buoyancy tanks to hull, ready to be trimmed and filled.

reinforced plastics, for roofs of vans and trains, and in these applications problems arise relating to large surface areas to be covered and the need of freedom from buckling and wrinkling with a high resistance to the atmospheres associated with long underground tunnels.

An example described by[1] Mr. P. A. Dunn, of C.I.B.A. (A.R.L.) Ltd., which may well foreshadow increasing use of resins and reinforced plastics in the precision tool industry, was the production of a surface table. In this process a master prepared-granite table is used to produce a suitable mould. To this mould is added a resin and hard filler, into which is embedded a roughly-prepared granite block. The working surface of plastics is thus a direct and accurate reproduction of the original master block.

Polyester resins which are used in the production of reinforced plastics are supplied as mixtures of resins and suitable monomers, usually styrene or methyl methacrylate. Due to the presence of monomers, resins are supplied as viscous liquids and, in production, the mixture is changed into an infusible and insoluble solid matter. This is achieved by polymerisation and cross-linkage of resin and monomer. This polymerisation or cure of the material can be effected by a rise in temperature, exposure to ultra-violet light, or use of a suitable catalyst, the last name being most popular and cheaper.

The aim of the Reinforced Plastics Conference was to link the manufacturers of the raw materials with industry, and in this aspect the conference was undoubtedly successful. There is an apparent need for standardisation in testing the mechanical properties of reinforced plastics so that some measure of direct comparison may be made. To this end a committee is being set up by the British Plastics Federation to investigate and make the necessary recommendations.

To use reinforced plastics to their full advantage, it may be desirable to depart from design procedure used with conventional materials, and to persuade manufacturers to do this is one of the biggest problems that face the plastics industry. As one speaker suggested, there is a definite need to educate industry in the correct use of reinforced plastics. As with most materials, reinforced plastics should not be regarded wholly as substitutes but, rather, they should be complementary to those which are at present used in coach building, boat building, press tool manufacture and in the chemical industry.

CELLULOSE ACETATE
MOULDING MATERIALS

Engineering Materials and Design
DATA SHEET No. 5

	Units	GRADE				
		Very Soft 108–122°C.	Soft 123–137°C.	Medium 138–152°C.	Hard 153–167°C.	Very Hard 168–182°C.
Mechanical Properties Tensile strength	p.s.i.	1,500	2,200–4,200	3,000–5,600	4,000	5,500–7,600
Elongation at break	%	40	40	30	20	15
Impact strength BS.1524	ft. lb.	5	4	3	2	1
Izod impact strength	ft. lb./in.					
at 23°C. (ASTM D 256-47T)		—	2.0–5.2	1.1–4.0	0.4–2.7	
at −40°C. (ASTM D 758–48)		—	0.4–0.8	0.3–0.7	0.2–0.6	
Flexural yield strength	p.s.i.	—	2,000–7,100	3,700–10,100	6,400–16,000	
Compressive yield strength	p.s.i.	—	1,900–5,100	2,800–7,000	4,700–9,300	
Hardness (Brinell)		—	—	—	—	up to 9
Modulus of elasticity	p.s.i. $\times 10^5$	0.4–1.4	0.8–1.8	1.5–3.0	2.5–4.0	3.5–5.0
Thermal Properties Rate of burning	in./min.	Not greater than 3				
Loss in weight on heating	%	8.0	6.0	4.0	3.0	1.0
Viscosity change (on moulding)	%	40	40	40	50	50
Specific heat	cal./g./°C.	0.3–0.4				
Thermal expansion	in./in./°C.	$1.0–1.5 \times 10^{-4}$				
Thermal conductivity	cal./sq. cm./sec./°C./cm.	$5–8 \times 10^{-4}$				
Heat distortion temp. at 65 p.s.i.	°C.	—	55–67	62–87	82–119	
at 264 p.s.i.	°C.	—	44–57	47–76	60–113	
Electrical Properties Power factor @ 800 c.p.s.	—	0.020–0.025				
Permittivity @ 800 c.p.s.	—	6.4	6.2	5.9	5.8	5.3
Volume resistivity	ohm–cm.	$10^{11}–10^{12}$				
Electrical strength @ 23°C. Normal conditions		350–500 volts per mil				
humid conditions		150 volts per mil				
General Specific gravity		1.27 to 1.31				
Refractive index	n_D^{23}	1.45 to 1.5				
Loss in wt. on leaching	%	5.5	4.2	3.0	2.0	1.0
Moisture absorption (72 hr. at 23°C. 100% R.H. sheet 0.060 in. thick)	%	2.8–4.0	3.2–4.3	3.5–4.7	4.0–5.0	4.8–5.8
Colours		Available in transparent or opaque colour ranges				
Chemical resistance		Resistant to oils, dilute acids and alkalis. Attacked by strong acids or alkalis				

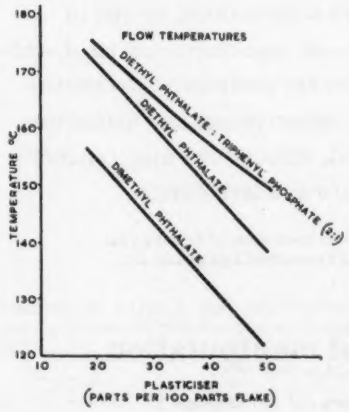
Data by courtesy of Yarsley Research Laboratories Ltd.

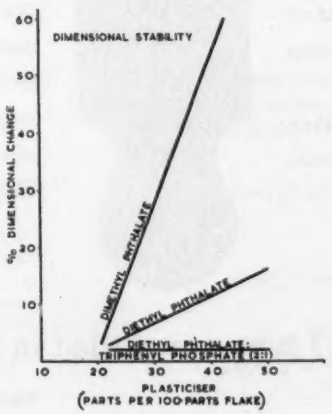
The composition, treatment and testing requirements for cellulose acetate moulding materials are set out in B.S. 1524: 1955

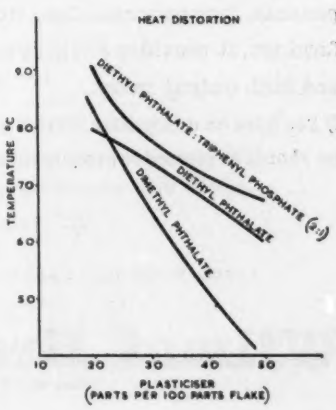
Effects of Solvents on Cellulose Acetate

Ethyl alcohol—B
Methyl alcohol—B
n-Butyl acetate—B
Amyl acetate—B
Ethyl acetate—A
Butyl alcohol—B
Acetone—A
Ethyl methyl ketone—A
Toluene—B
Benzene—B
Carbon tetrachloride—C
Ethlene dichloride—A
Ethylene glycol monoethyl ether—B
Chloroform—A

Effect: A—Complete solution. B—Decrease in shear strength to a constant value with no dissolution. C—No effect.

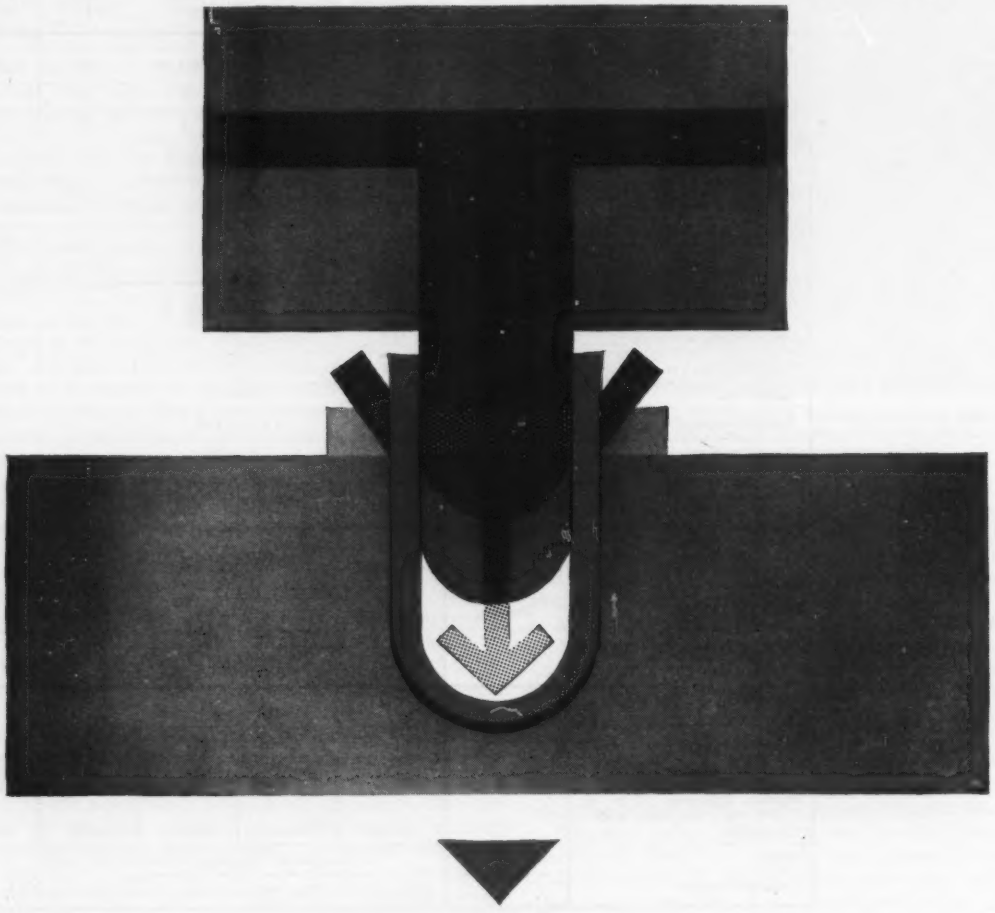






EMD 226 for further information

A new way with Pistons



Wilmot Breeden have recently developed a method of cold working (drawing and rolling) shells to close tolerances and high surface finishes. Applied to the quantity production of precision components, formerly machined from bar or forgings, it provides striking economies and high output rates.

If you have an application for this new method we should be pleased to investigate and advise.

The piston illustrated here has a diameter of 1.4". It is cold drawn from sheet steel, and the neck and spherical end are produced by rolling. Surface hardness is 750 VPN. The benefits from this process are a substantial saving in materials and manufacturing time, and freedom for the designer to secure the maximum effectiveness and utilisation of material, through the maintenance of grain flow and structure.

The illustration is by courtesy of Joseph Lucas (Hydraulic and Combustion Equipment) Ltd.

Wilmot Breeden are skilled in metal manipulation

Wilmot Breeden Ltd, Birmingham 1.

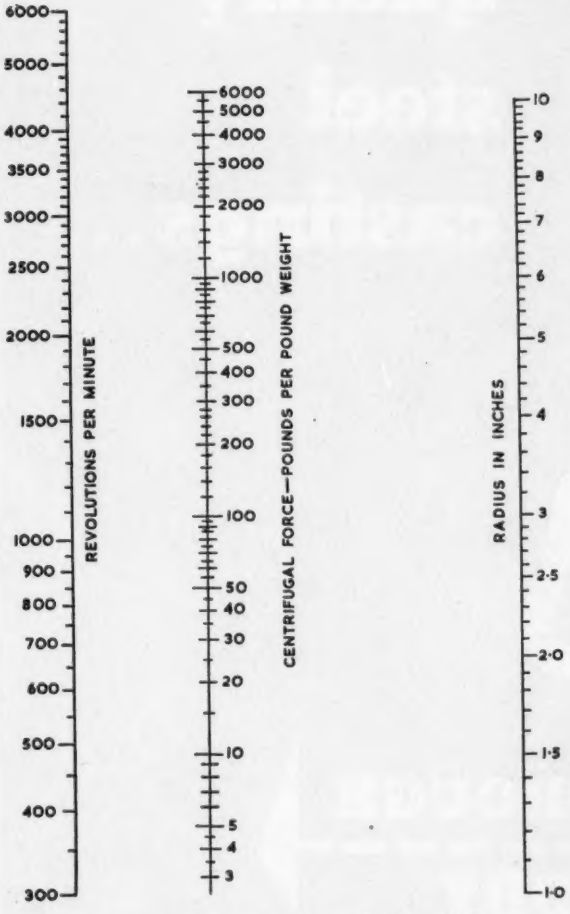
ANGULAR MOTION

Engineering Materials and Design
DATA SHEET No. 6

Centrifugal Force is the force exerted by a body revolving in a curved path and restrains it from moving in a direction tangential to that path.

$$F = \frac{Wv^2}{gr} \text{ or } F = M\omega^2 r$$

where F = centrifugal force (lb.)
W = weight of body (lb.)
$M = \text{mass of body } (\frac{W}{g})$
r = radius of curved path (ft.)
g = acceleration due to gravity (ft./sec.²)
$\omega = \text{angular velocity } \frac{v}{r} \text{ (radians/sec.)}$
$v = \text{linear velocity (ft./sec.)} = \frac{2\pi Nr}{60} \text{ r.p.m.}$



CENTRIFUGAL FORCE, LB. PER 1 LB. WEIGHT

Centripetal Force is the radial inward force acting on a body moving in a curved path and is equal in magnitude to the centrifugal force.

$$F = \frac{Wv^2}{gr} \text{ or } F = M\omega^2 r$$

Moment of Inertia is the measure of resistance of a rotating body to a change in angular velocity.

$$T = I\alpha$$

where I = moment of inertia (lb./ft.²) $\sum \frac{w}{g} r^2 = \frac{wk^2}{g}$.

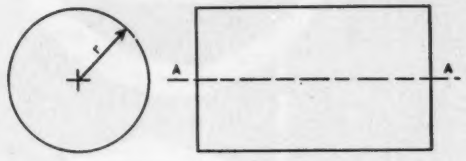
T = torque or couple (lb./t)
α = angular acceleration (radians/sec.²)
$\frac{w}{g}$ = incremental mass

The moment of inertia of a composite body is the algebraic sum of the moments of inertia of the individual bodies forming it.

Radius of Gyration is the radius at which the mass of a body is considered to be concentrated, the moment of inertia remaining unchanged.

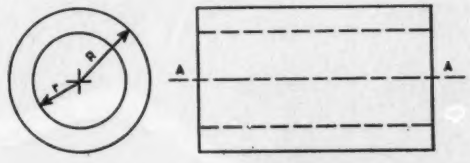
$$k = \sqrt{\frac{I}{M}} \text{ or } k = \sqrt{\frac{Ig}{W}}$$

where k = radius of gyration (ft.)
I = moment of inertia
m = mass of body
r = distance from axis at which M is acting
g = acceleration due to gravity (ft./sec.²)



$$I_{AA} = \frac{Mr^2}{2} = \frac{Wr^2}{2g}$$

$$k^2_{AA} = \frac{r^2}{2}$$



$$I_{AA} = \frac{M(R^2 + r^2)}{2} = \frac{W(R^2 + r^2)}{2g}$$

$$k^2_{AA} = \frac{R^2 + r^2}{2}$$

If angular acceleration $= \alpha$
Radial acceleration $= \omega^2 R$
Tangential acceleration $= \alpha R$

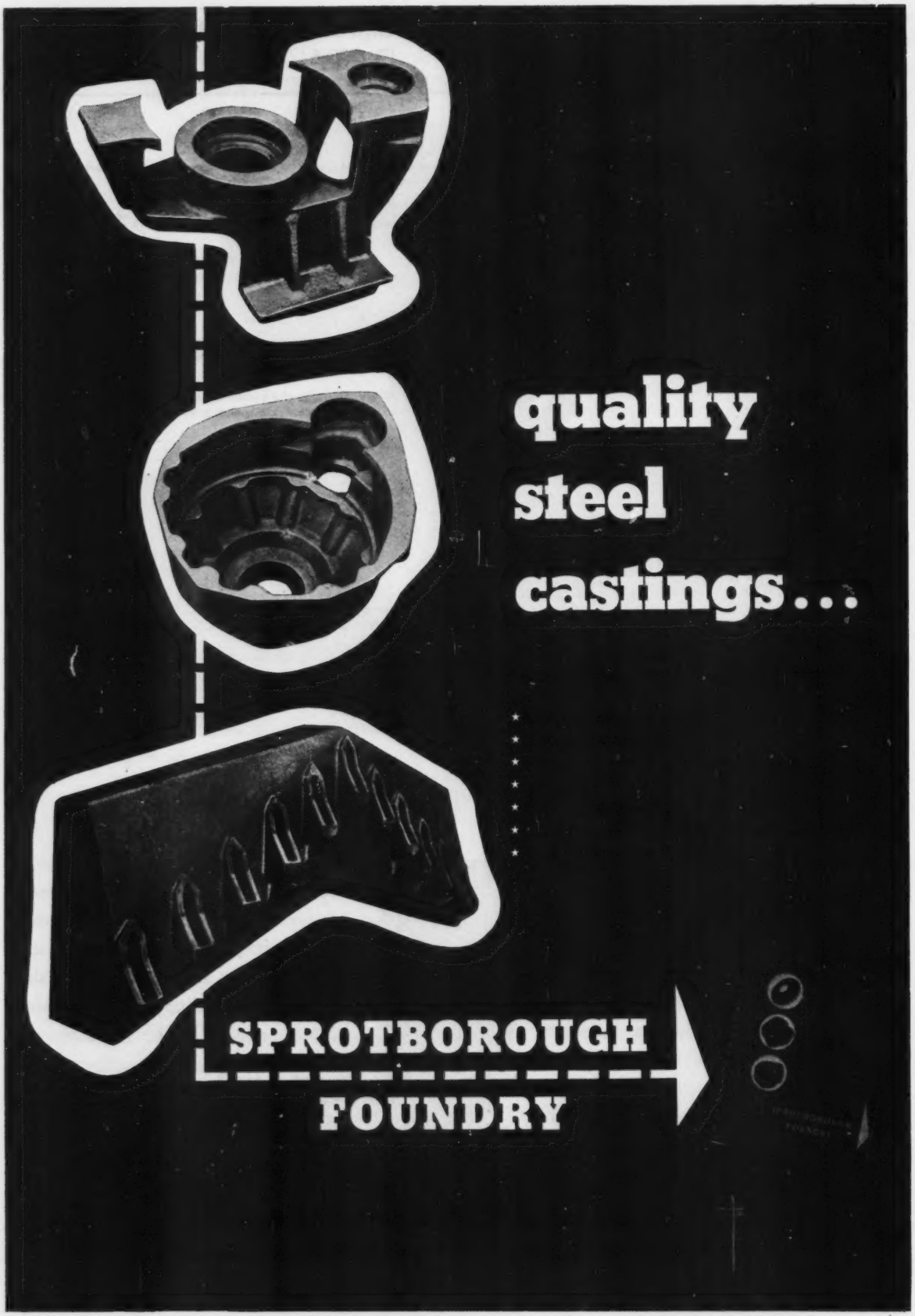
Kinetic Energy is the energy of a body due to its velocity.

$$KE = \frac{I_o\omega^2}{2}$$

where I_o = moment of inertia about axis of rotation

$$KE = \frac{I_o\omega^2}{2} + \frac{Wv^2}{2g}$$

where I_o = moment of inertia about parallel axis through the CG of the body.


quality
steel
castings...
SPROTBOROUGH
FOUNDRY

EPOXY-GLASS NOW FOR PRESSURE VESSELS

FROM OUR OWN CORRESPONDENT

IN aircraft and missiles, where weight is at a premium, reinforced plastics have become a reliable and proven pressure-vessel material. Spherical plastics pressure vessels —used experimentally five years ago—are now being used for the storage of compressed gases for jet-starting systems, fuel tank purging units, actuation of emergency equipment, such as seat ejection, launching torpedoes from surface ships and many classified uses. Promising future civilian applications include tanks for pneumatic brake systems in commercial aircraft and trucks, aqualungs for diving equipment and low-pressure gas tanks for caravans.

The most popular types of plastics pressure vessels for military use are designed for 3,000 or 5,000 p.s.i. operating pressures over a service life of 10,000 to one million cycles (from zero to full operating pressure and back to zero), and for service temperature ranges of −55 to 95 deg. C.

The materials system found most effective is a glass-fibre epoxy laminate with an SBR (styrene-butadiene) or GR-S rubber liner. By filament winding the pressure bottles, maximum strength laminates are produced, since the glass fibres are stressed primarily in tension. Mechanisation of the process provides a high degree of reproducibility of strength and quality.

Epoxy resin systems are used instead of polyesters because of the epoxies' higher ultimate strength and higher fatigue strength. Relatively precise S-N curves have been developed, from which both maximum allowable design stress and a safety factor can be determined in designing a bottle for a specific pressure cycle (fatigue) life. For example, bottles to be used at 3,000 p.s.i. operating pressure (5,000 p.s.i. proof pressure and 6,667 p.s.i. minimum burst) and 10,000 cycle life are designed with a value for maximum allowable design stress of 40 per cent of the ultimate strength of the material, or 28,000 p.s.i. The percentage value is selected from the S-N curves at the 10,000 cycle fatigue level. For one million-cycle bottles, maximum allowable design stress is 25 per cent of ultimate, or 17,500 p.s.i.

According to Apex Reinforced Plastics, reinforced plastics pressure vessels have several advantages over metals: (i) compared with a 32-lb. steel bottle designed for the same type of service, a reinforced plastic bottle weighs 16·5 lb.; (ii) a major benefit to the military is that the plastics bottles resist shattering on impact of gunfire—gunfire tests show no tear qualities or shattering in the laminate; (iii) plastics have a degree of resistance to corrosion and weathering superior to any of the pressure vessel metals, even aluminium.

Fibre-reinforced Ceramics

Large, non-brittle ceramic shapes with extremely good strength-to-weight ratios and high resistance to thermal shock result from a newly-developed ceramic fabrication technique—still in the development stages by Horizons Inc. Filament winding, long used to produce reinforced plastics parts, now appears promising for producing a fibre-reinforcing ceramic shape.

Essentially, the process involves saturating a monofilament or roving with a ceramic colloid and wrapping it around a mandrel on a lathe-like device. The part is then heat treated at about 540 deg. C. Due to the smallness of the colloidal particles, no higher firing temperatures are required.

Major feature of the process is the ease of fabricating large shapes, such as ten-foot radomes. Also, the reinforcing fibre imparts a degree of resilience to the ceramic body. Parts are oxidation proof and have high thermal insulating values. Though structures are not impervious to moisture, they can be made so by coating.

The factor limiting maximum-use temperature is the type of fibre used. Since no better ceramic fibre is available, Horizons are currently using commercial glass fibres as reinforcement. The nature of the ceramic colloid is undisclosed.

High-strength Vacuum-melted Alloy

A new precipitation hardening, nickel-base alloy has been developed by the General Electric Co. which possesses high strength in the 870-980 deg. C. temperature range. Designated René 41, the material is designed for severely-stressed high-temperature parts such as jet engine components and high-speed airframes. Strength tests of the new material with optimum heat treatment show that its 0·2 per cent offset yield strength at 650 deg. C. is 125,000 p.s.i. Its 100-hr. stress rupture strength at 870 deg. C. is 25,000 p.s.i. René 41 offers a 40-60 per cent improvement in sheet tensile strength over existing commercial materials at 540-760 deg. C., yet it can be produced with relative ease in sizes required to manufacture large sheet-metal components.

In addition to its high temperature strength, the material is highly resistant to corrosion and oxidation. It can be readily forged, formed and welded. Spot welding as well as inert arc welding (with or without filler materials) can be used.

Dust-free Mouldings from Polystyrene

Development of "low static" polystyrene resins that can be injection moulded into products having virtually no attraction for dust particles has been announced by the Monsanto Chemical Co. Designated as Lustrex Lo-Stat, the materials practically eliminate the electrostatic fields that draw dust and arrange it in unsightly patterns on the surfaces of moulded pieces.

Normally, the affinity of polystyrene for dust is caused when moulded parts leave the injection machine with an excess or deficiency of surface electrons. Since conventional polystyrene is a non-conductor, a non-uniform electrostatic field is retained on the surface which attracts and retains dust particles. However, the new polystyrene materials are formulated so that the moulded surfaces are sufficiently conductive to allow most of the positive and negative charges to neutralise one another. Thus, electrostatic charges and accompanying dust pick-up are eliminated.

The low static polystyrenes are especially recommended for such applications as displays, clock housings, furniture drawers, grilles for fans and air-conditioners, package closures, record player arms, and other speciality products which are expected to be decorative as well as functional.

WHAT'S NEW IN MATERIALS & COMPONENTS

Vinyl Foam

A new material known as Duflex, manufactured from vinyl plastics, has flexible cushioning properties and compresses in almost direct proportion to load. It does not bottom or give way suddenly, as it is composed of interconnecting cells which allow for free air passage. It is claimed to be entirely impervious to prolonged exposure to high humidity and to be resistant to acids, alkalis and a wide range of greases and solvents. Elson & Robbins Ltd.

EMD 261 for further information

Honeycomb Rubber

A new type of honeycomb rubber sheeting for anti-vibration — Recticel patented rubber—is manufactured in sheets of maximum size, 6 ft. × 4 ft., in

a thickness of approximately ¼ in. It is claimed to have remarkable anti-vibration and slip-resistant qualities, and to be suitable for all bench mountings, being equally effective from 0 per cent to 75 per cent depression. This new rubber is manufactured in the U.K. under licence from the Continent. A. Tout & Sons Ltd.

EMD 262 for further information

Aluminium Wire

A new product is aluminium wire continuously anodised by the Anodal process which provides the surface of the wire with an integral film of aluminium oxide. An outstanding feature of the Anodal film is its excellent insulating properties, and electrical purity aluminium wire treated by this process may be used for many types of electrical windings with considerable savings in wire cost. Wire in other aluminium purities and certain aluminium alloys, treated by this process and suitably dyed, is an economical material for the manufacture of a wide variety of products.

The treated wire is freely available in a range of standard British sizes from 16 s.w.g. (0·064 in. dia.) to 26 s.w.g. (0·018 in. dia.) and standard metric sizes from 1·60 mm. to 0·45 mm. dia.; the supply of non-standard sizes within this range and finer sizes down to 36 s.w.g. (0·0076 in. dia.) or 0·20 mm. dia. will be considered on request. Small rectangular sections can also be supplied. Aluminium Wire & Cable Co. Ltd.

EMD 263 for further information

Heat-transfer Sheets

A recent introduction is the range of Kynal heat-transfer sheets which offer several advantages over conventional tube/sheet combinations. The tubes are integral with the sheet and so give highly efficient heat transfer combined with neat patterns and low tooling costs. Maximum dimensions at present supplied are length 100 in., width 15 in. and material thickness 0·06 in. This material promises to have important applications in the construction of refrigerator evaporators, food processing equipment and oil and water coolers. I.C.I. Ltd.

EMD 264 for further information

Sprayed Moly-disulphide

Lubricant containing molybdenum-disulphide is now available in Aerosol form and may be obtained in convenient small canisters. The particle size is claimed to be so small that it is maintained in colloidal suspension. Unlike conventional lubricating oils, molybdenum-disulphide does not "throw", and so it is recommended for the lubrication of textile and food machinery. John W. Miller & Son Ltd.

EMD 265 for further information

Sprayed Ceramic Materials

The deposition of ceramic materials on metal by spraying at a temperature of 1,650 deg. C. is now carried out in titanium oxide, zircon and alumina; highly abrasion-resistant properties are claimed for the coatings. By firing in a reducing atmosphere, it has been possible to produce conductive coatings, particularly useful where static electricity is encountered.

Although coatings of this type are at present mostly used in textile thread guides, recent developments in the quality of the coatings produced have attracted the attention of pump manufacturers in search of new seal face materials. Telegraph Condenser Co. Ltd.

EMD 266 for further information

Epoxy-pitch Paint

This product, known as E/P, has been formulated to fulfil the industrial requirement for a coating of exceptional thickness combined with good resistance to chemicals, oils, fats and general corrosive conditions. To the water resistance and thicker film of a pitch coating is added increased chemical resistance and hardness of epichlorhydrin resins.

Being thixotropic, the material is very easy to apply and as much as 0·010 in. thickness can be built up with as little as two coats. It will be appreciated that to reach this thickness with conventional paints many applications would be required, necessitating much more expenditure on labour.

The paint is specially suggested for use on permanent structures such as cranes, bridges, as a lining for tanks and tankers, and in particular for mechanical handling equipment which may be dealing with abrasive dusts.

By virtue of its thickness, and being a tough coating, E/P paint is claimed to be considerably more resistant to mechanical damage than are conventional materials. Detel Products Ltd.

EMD 267 for further information

Silicone Rubbers

The advent of silicone rubbers has made available a new range of elastomeric materials which are satisfactory over a considerably wider range of temperatures than hitherto. These rubbers, called Prescolastik, are made for general use, but are also available for special purposes over a wide range of hardnesses. Low-temperature grades are suitable for use down to minus 90 deg. C. and the high-temperature grades show improved heat stability at 300 deg. C. Special grades are available where low compression set is needed, for high strength and for fuel and oil resistance. These rubbers are available in cellular form and they may also be used for coating nylon, Terylene and glass fabrics. Precision Rubbers Ltd.

EMD 268 for further information

Release-coated Papers

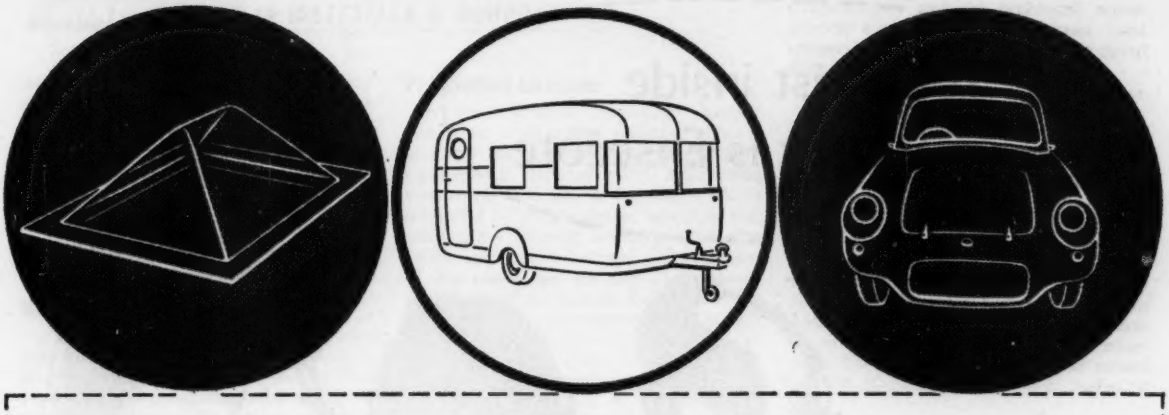
A range of backing and interleaving papers coated with special silicone and plastic finishes to provide any required degree of resistance to adhesives is being produced in the U.K. for, it is understood, the first time. They are being marketed under the name of Striplac, and are designed for the protection of all types of adhesive-coated or "sticky" commodities, in handling, storage or retail packaging.

These new papers are suitable for a wide variety of industrial applications. Obvious examples include the protection of sheet plastics or uncured rubber during storage and interfactory transit, as well as of various types of asbestos and

FOR MORE INFORMATION
about any of the products mentioned on these pages, please use the special reply card bound in this issue.

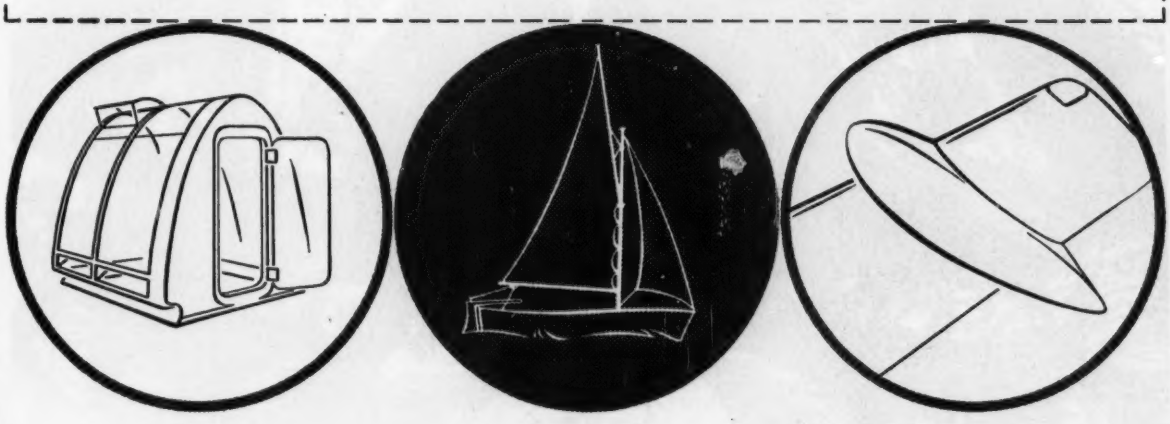
READERS' ADVISORY SERVICE
We shall be pleased to help readers who have difficulty in tracing sources of supply of materials or components.

EMD 228 for further information



For the manufacture of

POLYESTER RESINS



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AVAILABLE FROM U.K. PRODUCTION

People who pride themselves on their good equipment speak of ENSECOTE in a personal way. ENSECOTE protective plastic linings can be applied almost anywhere to almost anything. They are easily cleaned and sterilised, completely odourless, tasteless—and economical to install because larger vessels can be lined on the spot. ENSECOTE is particularly useful, too, for renovating glass lined tanks. The Dairy, Brewing, Paper and Chemical Industries—and all who own rail and road storage tanks —will find ENSECOTE invaluable as a protection against wastage due to deterioration.

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resin-impregnated products which are sticky at certain stages of manufacture. Other potential users will be the motor, aircraft, shipping and building industries —for such purposes as the packaging and protection of bitumen compounds, adhesive-backed upholstery, wall and roof linings, wallboards and other cladding. R.W.P. Co.

EMD 269 for further information

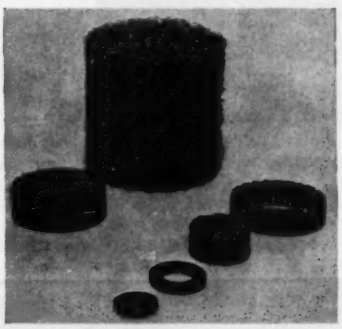
Metal Surface Primer

An opaque solution which will dissolve light rust and oxides and bond firmly to all metal surfaces as a form of surface primer is now being marketed under the name of Jenocote. On ferrous metals it produces a protective phosphate coating bound in plastic. It may be applied to almost any kind of surface, including sandblasted or gritblasted steel, cold-rolled and close-annealed steel, chemically-descaled or flame-descaled steel, as well as aluminium and most non-ferrous metals and alloys. The material itself is unaffected by petrol, oil and similar hydrocarbons, mild alkalis and mild acids and will not react with most plastics and rubber. It is claimed that all types of cellulose, synthetic paints, enamels, bituminous coatings, etc., may be successfully applied over Jenocote with marked improvement in adhesion. Jenolite Ltd.

EMD 270 for further information

Knitted Wire

A mesh structure knitted from a wide range of materials is being produced for a variety of products on special machines and can be produced to a large range of sizes and shapes. The mesh can be made with either laminated or round filament and can be crimped in a variety of pitches, depths and patterns. The nature of the mesh gives a surface area and free



volume which are both unusually large. Even a very open element with a free volume of 98 per cent can give a surface area of well over 100 sq. ft. per cu. ft. The loop structure gives strength and resilience. Mesh manufactured from stainless steel or Monel metal has many applications in high-speed aircraft for safety blankets and high-temperature seals. It can also be used for filters, shock absorbers and anti-vibration mounts. Knitmesh Ltd.

EMD 271 for further information

Protective Lacquer

A vinyl chloride/vinylidene chloride copolymer resin is now available which is intended for use where strong adherent coatings are required. The outstanding feature of Geon 222, as it is known, is its solubility in hydrocarbons, and it is also soluble in toluene, aromatic naphthas xylene and also in ketones. Thin coatings of this copolymer are said to withstand the effects of most acids and alkalis, salt water, corrosive atmospheres, oils, greases and food products. It has excellent adhesion to metal, glass, wood, masonry, paper and many other materials. It has particular application in such fields as paper coatings, food packaging and protective lacquers, as well as for caulking compounds. British Geon Ltd.

EMD 272 for further information

New Finishing Materials

The latest addition to the Parkerizing family of rustproofing processes, the Parker "F" process has been developed to meet the demand for a process which will deal with small amounts of surface rust and at the same time produce an iron phosphate coating conforming to the requirements of Defence Specification DEF-29 (Class 1).

Pyroclean No. 9 has been introduced as a material for heavy-duty immersion cleaning, but it may also be applied by spraying. Although principally designed for use before the bonderising or Parkerizing of ferrous metals, it is claimed that Pyroclean No. 9 is proving extremely use-for for a variety of heavy-duty immersion cleaning operations.

Preperite No. 3 is a new material for the removal of rust from iron and steel and corrosion products from non-ferrous metals. It is claimed to offer advantages of economy in operation, low chemical consumption, rapid action against rust and minimum attack on basis metal. It is suitable for spray, immersion or brush application. The Pyrene Co. Ltd.

EMD 273 for further information

Polyethylene Sleeve

For sealing the individual conductor joints in plastics-insulated communication cables against moisture, there is now available a silicone-grease-filled polyethylene sleeve, which is being marketed under the name of Polytel. With this sleeve, a water barrier need only be fitted to a cable at one end of each joint, thus preventing a "continuous pipe" effect being formed by the whole system.

The tubular polyethylene sleeves are sealed at one end and filled with a non-melting, non-solidifying, silicone grease of good dielectric properties, and which shows a high degree of water-repellence, oxidation resistance and a wide working temperature range. Tests are claimed to have shown that conductor joints protected by Polytel sleeves registered insulation resistances of 10^4 megohms and 5 $\times 10^4$ megohms respectively after (a) prolonged immersion in water of fluctuating temperatures, and (b) prolonged atmospheric exposure and subsequent total immersion in water. British Insulated Callender's Cables Ltd.

EMD 274 for further information

Acoustic Strips

Aluminium acoustic ceiling strips, known by the name of Dampa, are now being made available in this country. Basically, they consist of finely-perforated, stove-enamelled, narrow aluminium strips with an inlay of specially-processed mineral wool, combining a high capacity for sound absorption and insulation with light weight. The strips are fixed in place by simple lugs on steel supporting channels. The system of erection and nature of the aluminium strip also makes it

possible to produce a heated ceiling, allowing the engineer the maximum freedom in positioning and pipe run. For direct applications to existing walls and ceilings special panels are available as sound-proofings and insulating facings. Again, being extremely light, they can be easily and simply fitted to wooden battens with a stapling machine. Hurseal Ltd.

EMD 275 for further information

P.V.C. Fittings

A new range of pipe fittings moulded in Geon RA.170, a high-impact p.v.c., includes elbow bends, T-pieces, couplings, adaptors and flanges. This range of fittings now makes it possible to construct complicated systems of pipelines entirely in high-impact p.v.c. These fittings are claimed to be highly resistant to corrosive influences and mechanical damage. Extrudex Ltd.

EMD 276 for further information

Cold Junction Box

A cold junction box, for use when a large number of thermocouples are sited an appreciable distance from their indicating or measuring points, is now available. The unit can be installed on the plant and thermocouple leads gathered to it for automatic compensation. The distance from cold junction box to indicating/measuring point can then be covered by ordinary copper cable with a consequent considerable saving in cost.

In addition, the cold junction box gives greater accuracy than normal methods of compensation and is usually set to maintain a temperature of 60 deg. C. ± 0·1 per cent. This accuracy is essential for most forms of data handling.

The unit accommodates 16 pairs of copper constantan leads, the 16 compen-

EMD 230 for further information

"well in advance of current practice . . ."

Metalworking Production

FOR years, batch production has been the traditional method of producing pressure die castings. Line production, the "experts" told us, was out of the question. Our development engineers thought differently and our directors gave them full support. The degree of success our new "die-line" foundry has achieved can be summarised best by a few more quotations from leading technical, industrial and financial publications. "Ten day production cycle reduced to 24 hours . . . 50% more castings from the same floor area . . . production from raw materials to finished component under constant supervision . . . wasteful handling practically eliminated." This new development, which we feel will go a long way towards offsetting increasing production costs by greater efficiency in operation, helps us reduce your production costs. Your enquiries would be welcomed.

THE WOLVERHAMPTON DIE CASTING COMPANY LIMITED

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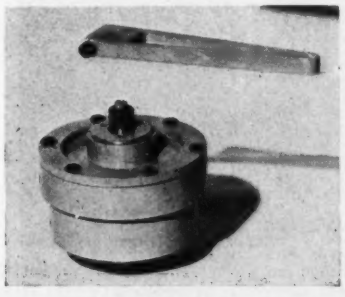
sating cables and a cold junction thermostat. A test thermometer can be inserted to check the performance of the latter. The case is dustproof and measures 11 in. wide × 20 in. high × 6 in. deep overall. Sunvic Controls Ltd.

EMD 277 for further information

Precision Dashpots

Precision dashpots are now available for damping vibrations, or cushioning and halting linear or rotary motion, in servo-mechanisms and in research apparatus. The standard cylindrical size is 2·5 in. dia. and 2·4 in. high; weight 0·5 lb. Other sizes can be made specially. The movement to be damped or halted is applied to the dashpot either by a lever or directly to a serrated spindle protruding from one end.



The damping rate varies from 50 to 2,000 lb. in. per radian per second. The maximum safe torque is 250 lb. in.

The dashpot has a special elastic seal to prevent the fluid leaking. It can be used any way up. Air pockets cannot form and there is no backlash.

Because the viscosity of silicone fluids varies very little, the performance of the dashpot tends to be constant over a wide temperature range. Kinetrol Ltd.

EMD 278 for further information

Vapourproof Fitting

A new 150/200-w. vapour-proof tungsten wellglass fitting for use in oil refineries, chemical plant and similar situations has recently been introduced. The fitting has a corrosion-resistant LM-6-M aluminium alloy canopy, tapped for top entry (1-in. electrical thread), and a heat-resisting wellglass protected by a galvanised wire guard. There is a 14-in. dia. p.v.c. reflector available as an optional extra and the fitting can also be supplied with either a 45-deg. angle entry or conventional side entry.

The wellglass is held in position by the galvanised wire guard by means of a screwed pad with brass wing-screw fastening which exerts pressure on the wellglass and Neoprene sealing gasket. To re-lamp the fitting, the pressure pad is released and the wire guard may then be lifted and rotated to free it from the top casting. The glass and guard is still retained in position by one lug and can be hinged to one side for re-lamping. A.E.I. Lamp & Lighting Co. Ltd.

EMD 279 for further information

Carbon Stack Controller

This new controller enables the starting resistance of a d.c. motor to be cut out in an infinite number of steps, thereby minimising wear and burn on contacts. The closing of the main contact introduces a resistance which limits the motor current to 70 per cent of nominal and, as pressure is applied to the carbon discs, their resistance falls continuously to about one-tenth of its initial value, and finally the whole resistance is short circuited by a contactor. The controller is specially suitable for the control of electric vehicles and it is fitted with a delaying device to ensure that it is foolproof against excessive acceleration. Horsepower ratings are from ½ to 6·6 and voltage ranges are 24, 36, 48, 64 and 72. Electro Dynamic Construction Co. Ltd.

EMD 280 for further information

Air-line Coupler

A new style of coupler called Quick-Fix has been introduced to provide instant connection and disconnection of air-operated equipment from air lines without waste of compressed air.

The new coupler consists of two parts —the coupler itself incorporating the special ball locking device, and the mating connector. The coupling action is achieved by inserting the connector into the coupler and simply pushing home. The steel balls of the coupler then lock the connector in position to provide a

perfect, air-tight joint. Quick release is effected by sliding the outer sleeve of the coupler along its body, which disengages the steel balls, releasing the connector. Tecalemit Ltd.

EMD 281 for further information

Self-adhesive Nameplate

A nameplate which requires no mechanical fixing or activating solvents is now being offered to a wide range of industries. Before application, the nameplate is soaked in warm water for a few seconds to enable the protective film to be removed and it is then fixed by firm pressure on to almost any surface which is clean and free from dust. The ease of application is claimed to allow the nameplate to be used in inaccessible positions at a low cost, as drilling and riveting are eliminated. All conventional types of metal or plastic nameplates, dials and scales can be applied in this way. Millett, Levens (Engravers) Ltd.

EMD 282 for further information

Air Filters

A new range of large-capacity air-filters has been introduced for the filtration of air breathed by internal combustion engines. The filter incorporates the Micronic paper element which has for many years been used for fuel and lubricating oil filters.

A new washable filter, suitable for crankcases and hydraulic reservoir breathing, is also available and air flows from 60-550 cu. ft./min. can be accommodated. Automotive Products Co. Ltd.

EMD 283 for further information

Steel Framing System

A steel channel framing system incorporating novel features is claimed to have many applications for storage racking, partitions, electrical trunking, and pipe and cable supports. Known as Unistrut, the system is based on a cold-rolled steel channel which permits attachments of fittings anywhere along its length. Attachments are made by means of a special nut which can be inserted into the channel at any point along its length. A spring holds the nut in position ready to accept a bolt and serrated grooves containing hardened teeth ensure that, when tightened, the nut bites into the channel and makes a specially firm fixing. The channel sections can be assembled into a variety of combinations by spot-welding and a comprehensive range of fittings is available to clip or bolt on to the channel. The elimination of drilling and welding, as well as much detail drawing, ensures complete freedom of adjustment and low cost. Sankey-Sheldon Ltd.

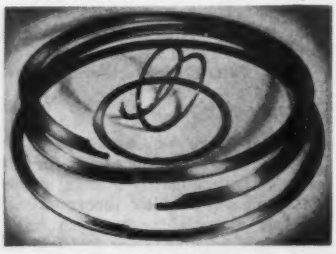
EMD 284 for further information

Retaining Rings

A modern method of securing component parts is by the use of Spirolox rings, which are manufactured either inspringing or outspringing, and consist of two turns of flat steel spring strip formed

in a continuous helix. They are concentric, with no projecting ears or lugs, and may be fitted and removed without circlip pliers or other special tools.

A small notch or slot is suitably placed at both ends to enable the retaining ring



to be eased out of its groove by a small screwdriver. It is claimed that they spiral into their grooves easily, saving many man-hours on assembly. For quick line assembly, tapered plugs or sleeves may be used. The Spirolox is suitable for mechanical assembly owing to its full concentric form without lugs. Their two-turn construction prevents tangling in bulk stock, thereby offering a further saving of time. Wellworthy Ltd.

EMD 285 for further information

Pipe Couplings

Swivel and ball couplings have been designed to allow for reciprocating or rotary movement on pipe joints where steam, water, air or oil are employed throughout industry. These fittings provide the flexibility of hose combined with the durability of rigid pipe, also maintaining a full-pipe section in all directions through 360 deg., thus ensuring no restriction in flow. They withstand pressures over 500 p.s.i. (steam) and temperatures up to 260 deg. C. Couplings are made in two distinct types: single and double swivel in sizes from ¼ in. B.S.P. to 2 in. B.S.P.; single and double ball from ¼ in. B.S.P. to 1 in. B.S.P.

Swivel couplings provide a full rotary action in one plane, and are supplied for right angle, parallel or straight-through pipe connections. Ball couplings provide a full rotary action and also 30 deg. angular flexing for applications where it is difficult to maintain correct alignment of pipelines. Both asbestos and Fluon joint packings are supplied. J.R.H. Products & Co. Ltd.

EMD 286 for further information

Socket Ball-type Cocks

A new range of socket ball-type cocks which incorporate a special plug as an operating unit offers a completely unrestricted circular passage without pockets and a tight seal in both directions of flow. These features make for extremely low flow resistance and do not permit turbulence in the operating medium. Effective sealing of the plug is ensured by special seals made from a variety of materials which are selected in accordance with surface conditions. The seals at the spherical plug are protected against contact with operating media only when the cock is fully opened or closed. Hydraulics & Pneumatics Ltd.

EMD 287 for further information

Thermocouple Amplifier

A new equipment for temperature measurement is available for use with thermocouples. The unit operates off 12-volt d.c. supply, resulting in inexpensive and safe wiring installation; the use of transistors results in low power consumption so that only a small battery is required. The output circuit is completely independent of any resistance change within wide limits and, therefore, the calibration is completely unaffected by the resistance of the transmission leads. Fielden Electronics Ltd.

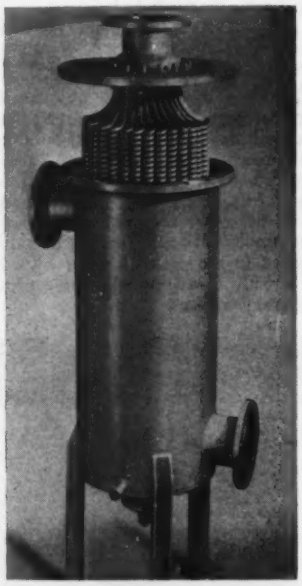
EMD 288 for further information

Heat Exchangers

An entirely new type of heat exchanger, called Helitube, has been developed for application in the heating and cooling of liquids such as would normally be carried out in calorifiers, heaters, heat transformers, condensers or evaporators.

The design is of particular interest, as it is a complete breakaway from the conventional hairpin and floating head type heat exchanger, and has many advantages over the conventional varieties because of its compact, efficient and serviceable design. The outer casing consists of a fabricated steel jacket and the nest of tubes can be either copper, steel, aluminium or stainless steel.

The Helitube heat exchanger surfaces consist of narrow tubes tightly coiled into a helical shape and housed in an external jacket. High quality seamless



tubes are used, and these are secured in the tube plates by means of a tight-fitting ferrule which beds the tube into grooves in order to effect a perfect seal. If steel tubes are used they are welded into the tube plates. Both methods of fixing the tube ends ensure a dead-tight seal and throughout their life there can be no movement of the tube ends. British Boiler Accessories Ltd.

EMD 289 for further information

Carter Gears Ltd.

A paragraph in our November issue suggested that the Carter F-type range of variable-speed gears was of recent introduction; this equipment has, of course, been marketed successfully for some years. We regret any inconvenience that this announcement may have caused to the manufacturers.

New Publications and Technical Literature

Johnson, Matthey & Co.: *Platinum Metals Review.* Latest issue includes articles on increasing the acid resistance of stainless steels and on platinum-coated titanium anodes.

EMD 290 for further information

Hellermann Ltd.: *An Insight into Plastics Extrusion.* Deals with progress of the company's production of plastics tubing.

EMD 291 for further information

Williams Alexandra Foundry Ltd. Brochure showing range of non-ferrous castings and machined components.

EMD 292 for further information

Whiffen & Sons Ltd.: Descriptions, specifications and applications for the company's Fi-Vi cellular rigid p.v.c. materials.

EMD 293 for further information

United Steel Cos. Ltd. *The Factories Acts, 1937 and 1948.* Revised edition of summary prepared by the company's safety consultant.

EMD 294 for further information

I.C.I. Ltd.: *Vinyl Chloride Plastics.* Brochure describing the many specific uses for which these were designed. *Silicone Rubbers.* Reviews the 19 silicone rubbers, gums and pastes produced by the company, together with properties and applications.

EMD 295 for further information

BX Plastics Ltd.: *Injection Moulding Materials.* Review of these materials and their applications.

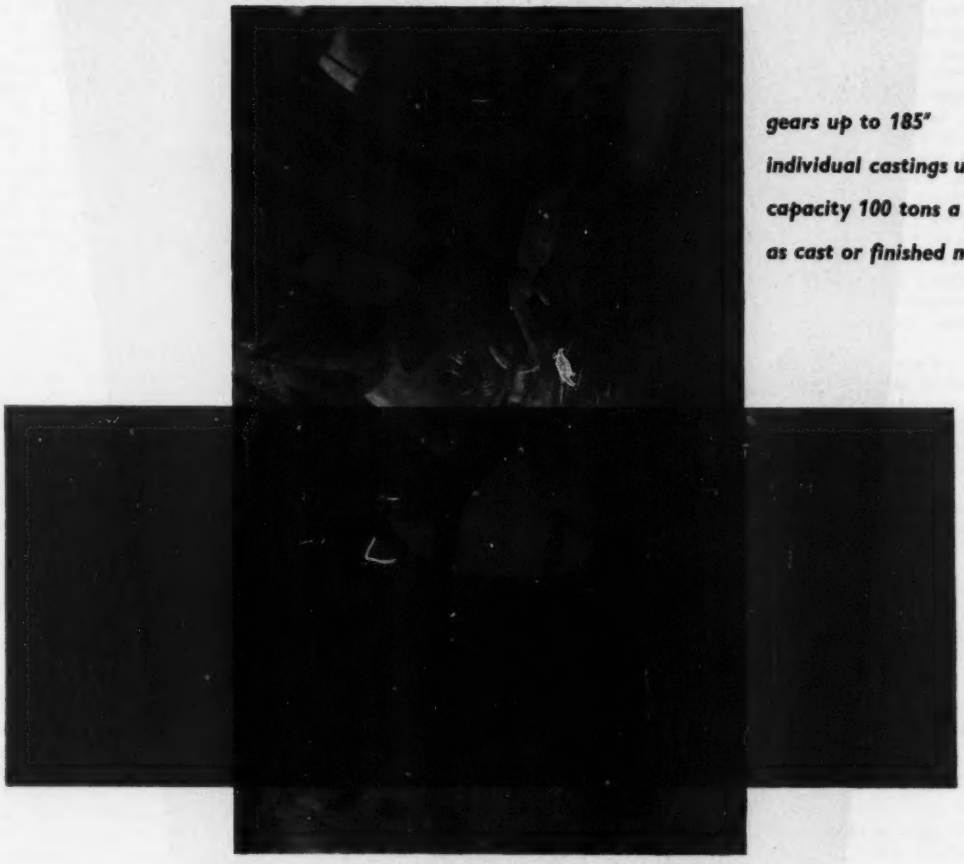
EMD 296 for further information

Mond Nickel Co. Ltd.: *High Tensile Aluminium Bronze Alloys for Marine Propellers.* Describes various technical and production factors involved and how they must be applied in practice.

EMD 297 for further information

EMD 231 for further information

fine steel castings



gears up to 185"

individual castings up to 7 tons

capacity 100 tons a week

as cast or finished machined

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no modern design department should be without a comprehensive set of Crofts Technical Publications Bona fide requests will be dealt with promptly by our Publicity Department at Bradford, or by any of the Branch Offices at: Belfast, Birmingham, Bristol, Cardiff, Dublin, Glasgow, Ipswich, Leeds, Liverpool, London, Manchester, Newcastle, Northampton, Nottingham, Sheffield, Stoke-on-Trent

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EMD 232 for further information

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C63a

News of Industry

Mr. E. W. Jackson has been co-opted to the council of the Institution of Engineering Designers to fill the vacancy left by Mr. P. E. Murphy.

Mr. T. A. Houghton has resigned as hon. secretary of the north-eastern branch of the Institution of Engineering Designers.

Mr. W. Gray has been appointed chief designer of A. Reyrolle & Co. Ltd.

Mr. C. S. Johnson, who was for seven years chief metallurgist at West Yorkshire Foundries Ltd. and later chief inspector at Leyland Motors Ltd., has been appointed foundry manager at the Farington foundry of the company.

Sir Donald Bailey, director of the Ministry of Supply's Military Engineering Experimental Research Establishment, has been co-opted to the council of the British Welding Research Association.

Mr. J. A. Gay has been appointed patents exploitation officer to the U.K. Atomic Energy Authority.

Dr. N. P. Allen, superintendent of the N.P.L.'s metallurgy division, is to deliver the 11th Hatfield Memorial Lecture on December 9 at the Institution of Naval Architects.

Mr. W. H. Devenish has been appointed deputy head of member relations department of the Electrical Research Association.

Mr. R. F. Webb, formerly a lecturer in natural sciences at Cambridge, has joined CIBA (A.R.L.) Ltd. to direct long-term research in new plastics materials.

Dr. J. C. Chapman, of the civil engineering department, Imperial College of Science and Technology, London, has won the second annual Gregory Award for his paper on "Application of Stud Welding to Vibrating Wire Strain Gauges". The award is sponsored by the U.S. associates of Crompton Parkinson (Stud Welding) Ltd.

Mr. W. Fishwick, professor of electrical engineering, University College of Swansea, and **Mr. S. A. Tobias**, assistant research director in Cambridge University engineering department, are to receive an A.S.M.E. award for their work in the field of vibration.

Mr. G. B. Warren, vice-president and consulting engineer of the turbine division, General Electric Co. of the U.S.A., has been elected president of the American Society of Mechanical Engineers.

Dr. H. M. Finniston has been appointed research manager of C. A. Parsons & Co.'s nuclear research centre at Newcastle upon Tyne.

Mr. G. F. W. Adler, chief development engineer at Rugby of English Electric Co., has been appointed chief mechanical engineer and a member of the directorate of engineering of Marconi's Wireless Telegraph Co. Ltd. with responsibility for all mechanical engineering design aspects, both of Marconi's and their associates, Scanners.

The design consultant firm of **Saben, Hart & Partners Ltd.** has now been merged with that of E. G. Irwin & Partners Ltd. Technical director Mr. E. W. Saben and chief engineer Mr. L. J. Clarke, along with technical personnel, have transferred to the parent company.

The **Council of Industrial Design** has announced the establishment of The Duke of Edinburgh's Prize for Elegant Design. It will be awarded for "a contemporary design in current production distinguished by its elegance and will be given personally to the designer of the chosen product; products shown at the Design Centre in London will be eligible. The prize, up to a value of £100, may be designed by the winner himself. The CoID will then arrange for its manufacture.

The **Plastics Institute** is to hold a conference on "Polymeric Progress" early in 1960. Details are to be issued nearer the date.

The **Design Research Unit** has moved to 37 Duke Street, London, W.1 (Tel.: Hunter 1681).

Activities of the **Tudor Accumulator Co. Ltd.** are to be merged with those of the D. P. Battery Co. Ltd., who will produce and market the lead-acid batteries previously supplied by the separate companies.

The name of the Aerograph Co. Ltd. has been changed to the **Aerograph-DeVilbiss Co. Ltd.**

Bristol Aeroplane Co. and the Aerojet-General Corp. of California have formed a new joint company known as **Bristol-Aerojet Ltd.**, in which they will combine the solid rocket motor technology possessed by each group. Plant will be located in the U.K., and will be devoted to development, manufacture, casting and testing of solid rocket motors, including propellent formulation.

Alfred Herbert Ltd. have been appointed sole distributors in the U.K. for measuring and inspecting equipment made by Censor of Liechtenstein.

The **Cincinnati Shaper Co.**, of Ohio, has formed a British company of the same name, with works at East Kilbride, near Glasgow.

A department of aircraft materials has been established at the **College of Aeronautics**, Cranfield, enabling students to take this subject as their main specialisation in the postgraduate College Diploma course. It will embrace engineering techniques in metals and non-metallic materials applications. It is also intended to set up a short course on materials, of about two months' duration, for industry generally, to provide a working knowledge of modern developments in materials theory and technology.

Manufacturers of products shown at the **Design Centre** in London may now indicate this in retail stores with a special black-and-white label issued by the CoID.

A new product group has been formed within the **Federation of British Rubber and Allied Manufacturers.** One of its objects is to exchange and co-ordinate technical information on the application and use of natural and synthetic rubber and ebonite linings.

Wakefield-Dick Industrial Oils Ltd. have introduced a new mobile Metafilter unit for the cold filtration of insulating oils on site. Unit operates at a circulation rate of more than 1,000 gals./hr.

We are asked to point out that the labelling machine shown on page 67 of our November issue is made by the Purdy Manufacturing Co.

Designer's Diary

Nov. 24. Inst. Prod. Eng. "Use of Rubber in Engineering". Grand Hotel, Hanley. 7.30 p.m.

Nov. 25. Inst. Prod. Eng. "Ceramic Cutting Tools". Walker Technical College, Oakegates. 7.30 p.m.

Nov. 25. Inc. Plant Eng. "Corrosion". S. Wales Engineers' Inst., Park Place, Cardiff. 7.30 p.m.

Nov. 28. Inc. Plant. Eng. "Statutory Regulations of Steam and Pressure Vessels". Imperial Hotel, Birmingham. 7.30 p.m.

Dec. 8. Inst. of Eng. Designers. "Hydraulic Machinery". 6 Higham Place, Newcastle upon Tyne. 7.15 p.m.

Jan. 2. Plastics Inst. Young People's Lecture. "Plastics and Electricity". I.E.E., Savoy Place, London, W.C.2.

Jan. 12. Inst. of Eng. Designers. "Design in Relation to the Production of Castings". 6 Higham Place, Newcastle upon Tyne. 7.15 p.m.

Jan. 13. Royal Aeronautical Socy. "Stress Corrosion". 4 Hamilton Place, London, W.1. 7 p.m.

Jan. 27. Royal Aeronautical Socy. "Noise Problem in Relation to Engine Design". 4 Hamilton Place, London, W.1. 7 p.m.

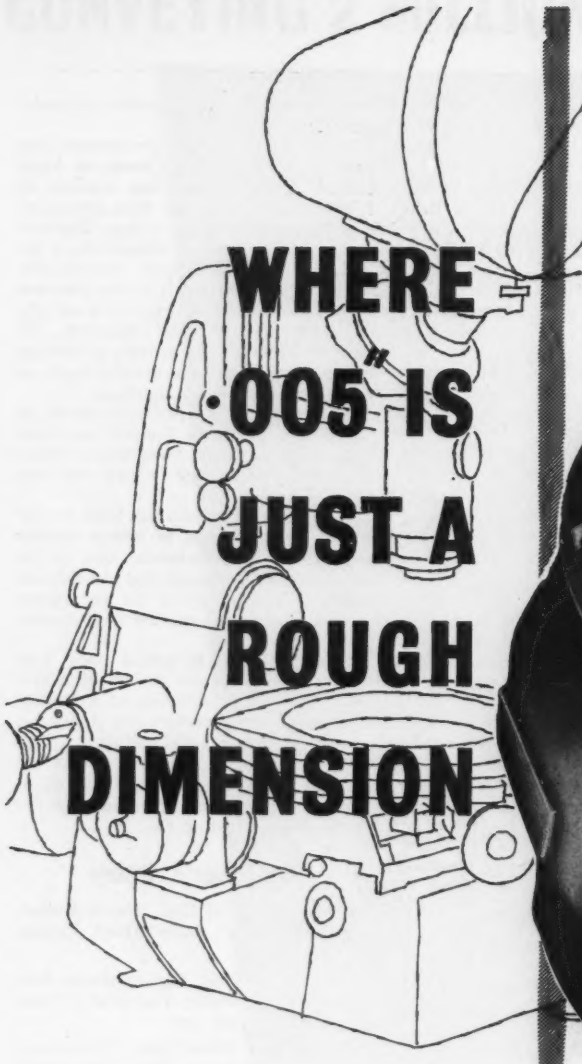
Feb. 20. Plastics Inst. "Recent Developments in Applications of Epoxy Resins". James Watt Mem. Inst., Birmingham, 6.30 p.m.

W. H. Devenish

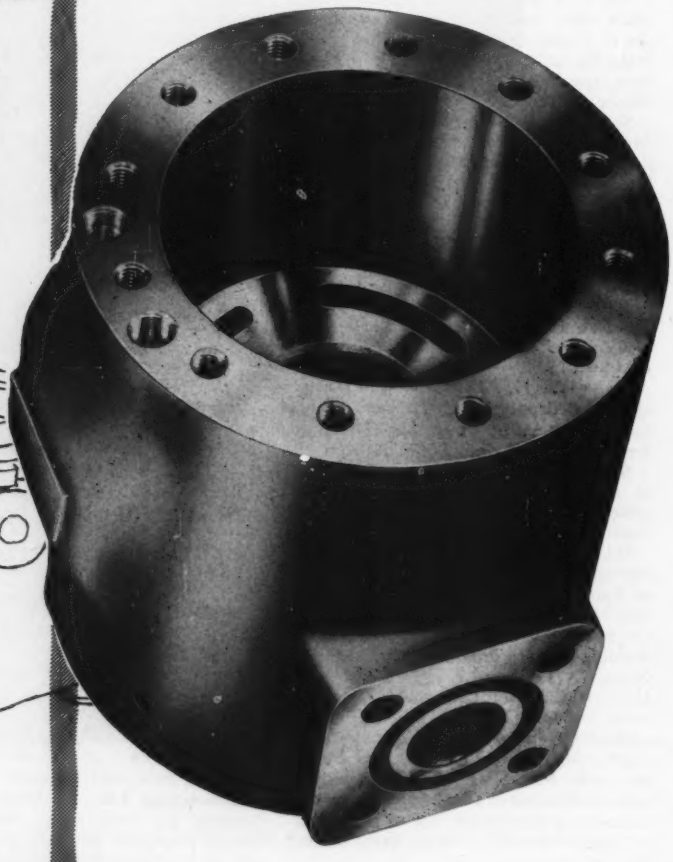
R. F. Webb

Dr. J. C. Chapman

WHERE ·005" IS JUST A ROUGH DIMENSION



Illustrated here is a hydraulic valve body for Stein-Atkinson Vickers Hydraulics Ltd., made by Harpers and machined by them to limits of ±·002"



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* *Details of the Harper Castings Service will gladly be supplied on request.*

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EMD 234 for further information

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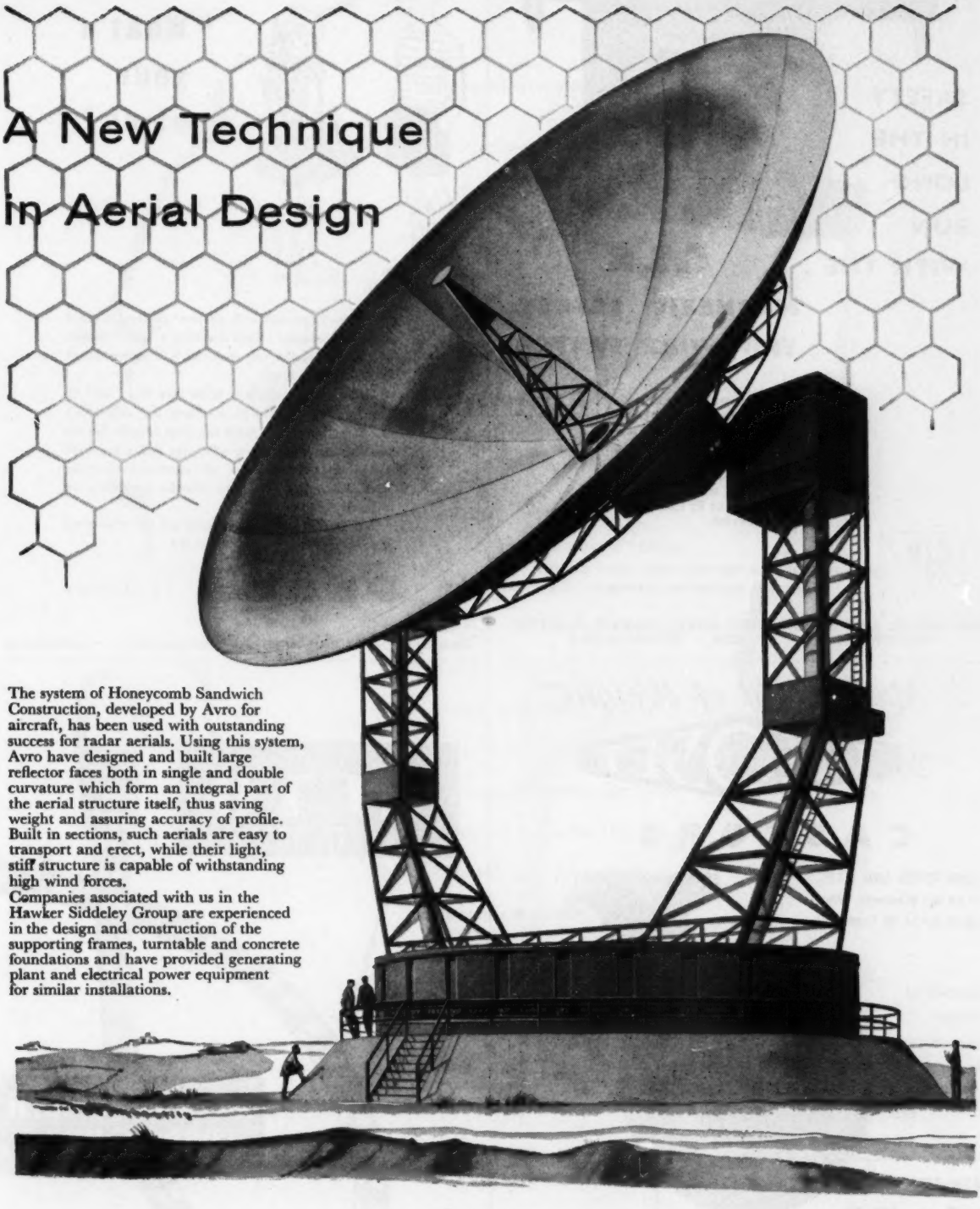

The system of Honeycomb Sandwich Construction, developed by Avro for aircraft, has been used with outstanding success for radar aerials. Using this system, Avro have designed and built large reflector faces both in single and double curvature which form an integral part of the aerial structure itself, thus saving weight and assuring accuracy of profile. Built in sections, such aerials are easy to transport and erect, while their light, stiff structure is capable of withstanding high wind forces.

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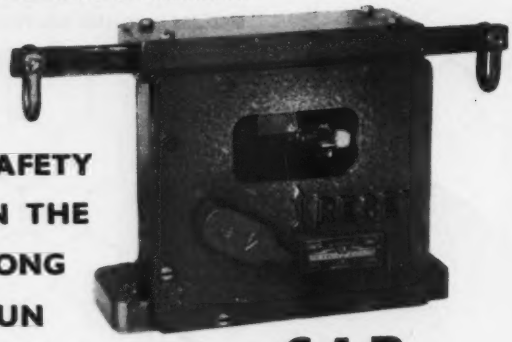

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EMD 236 for further information

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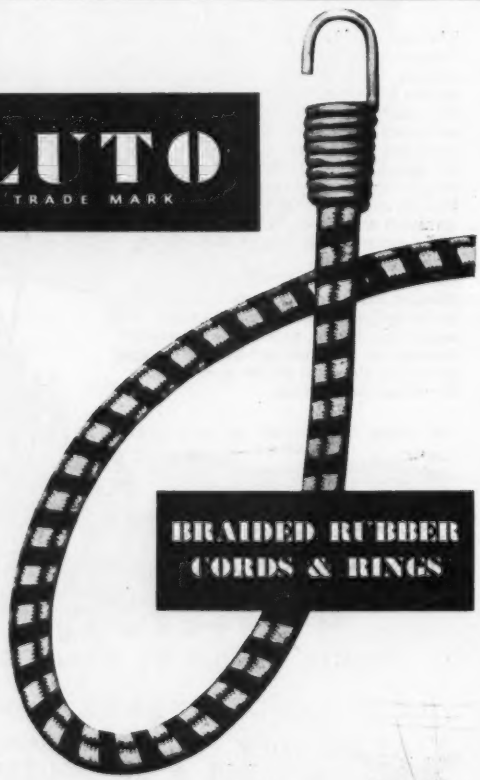

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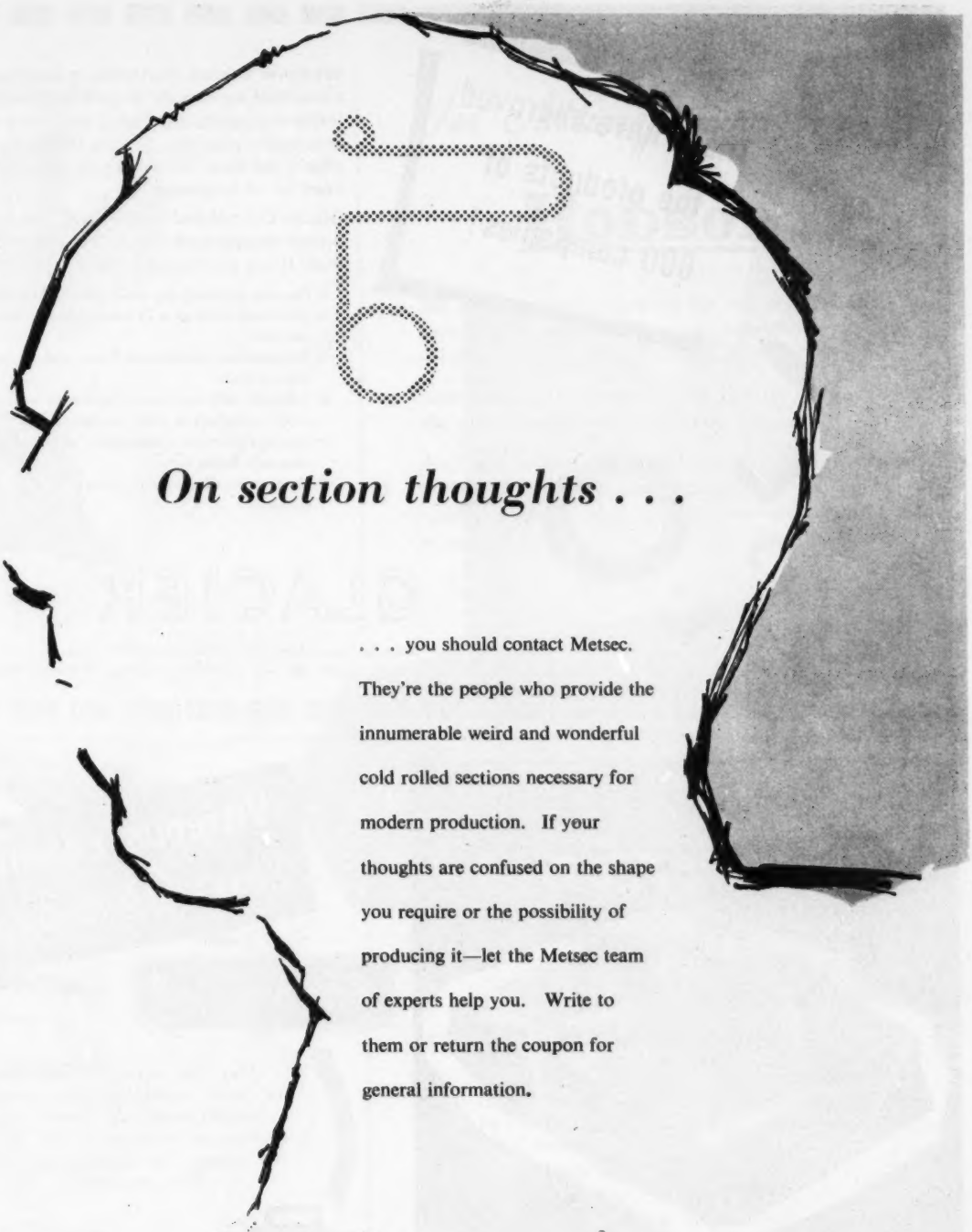

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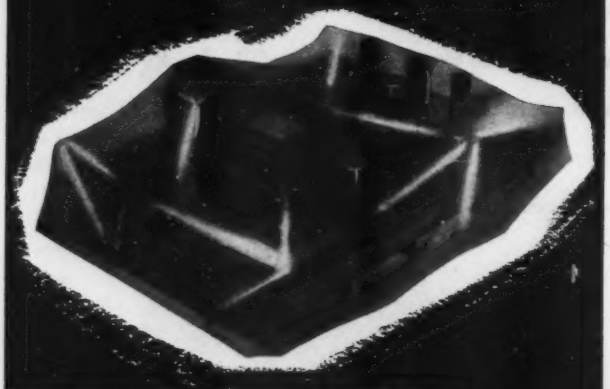

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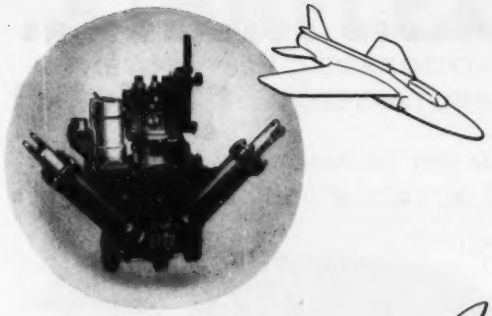

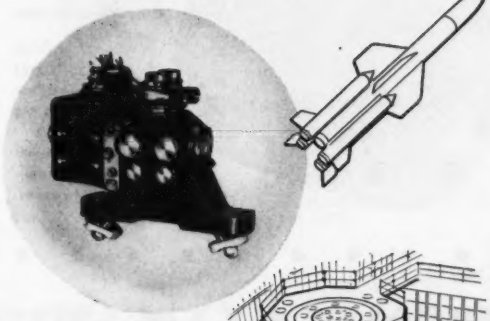

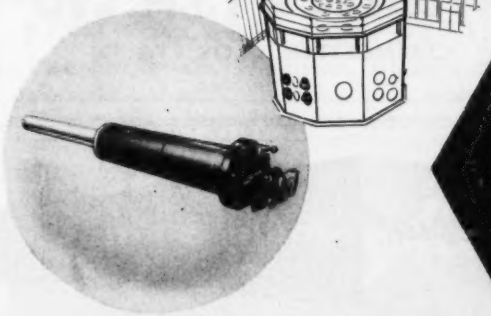

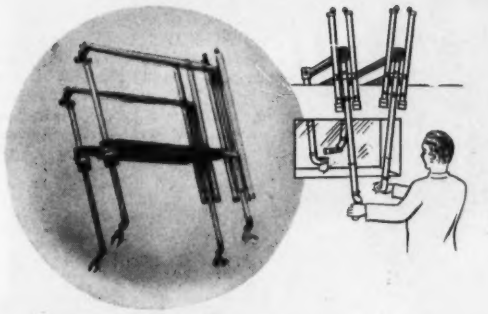

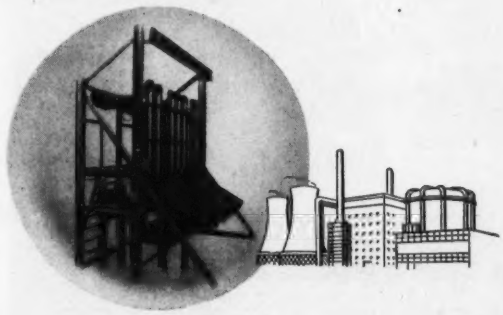

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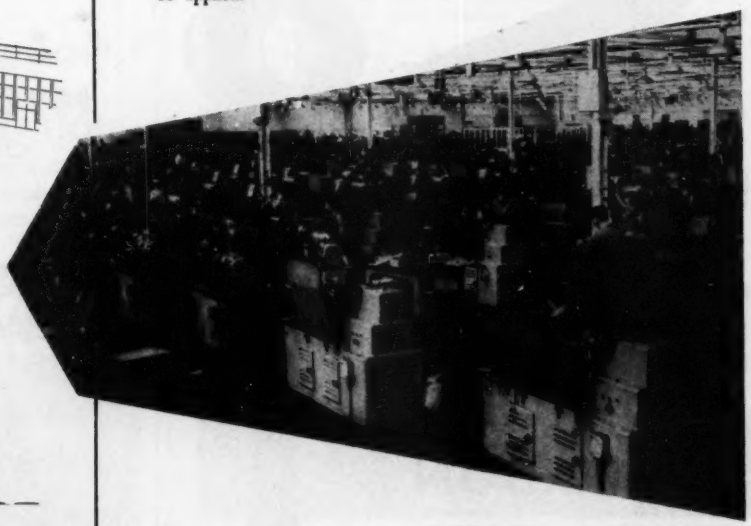

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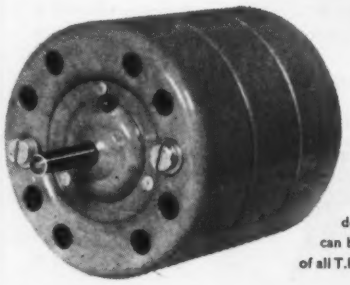

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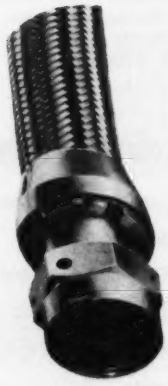

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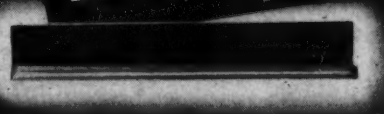

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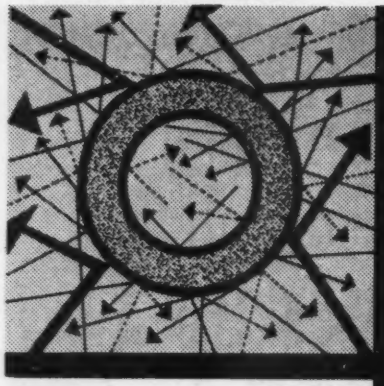

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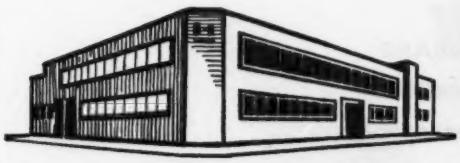

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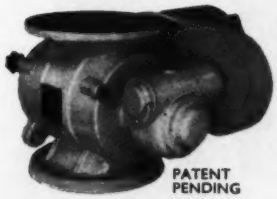

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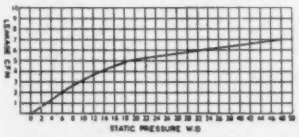

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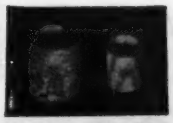

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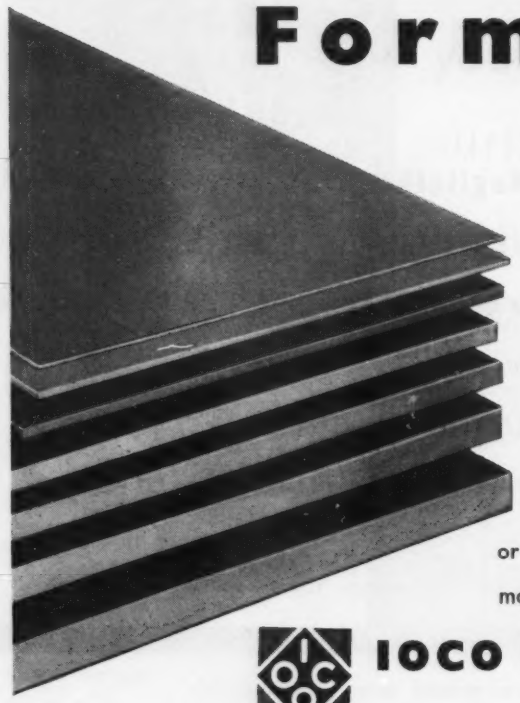

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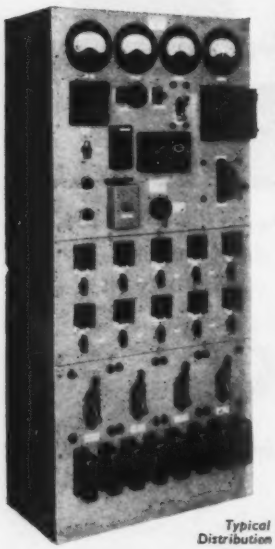

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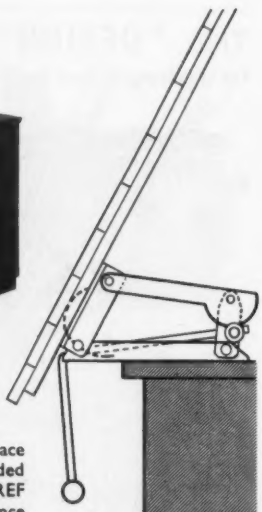

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